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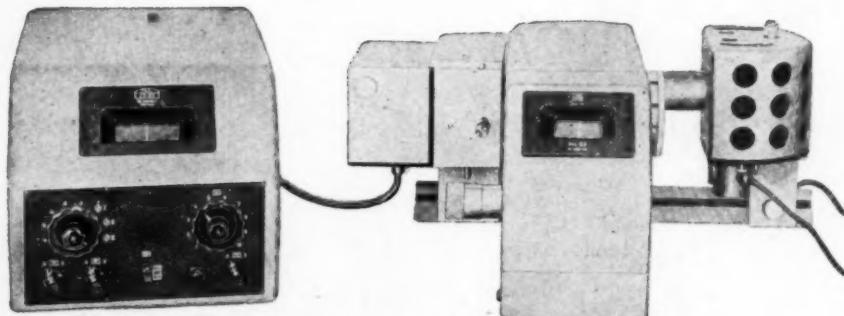
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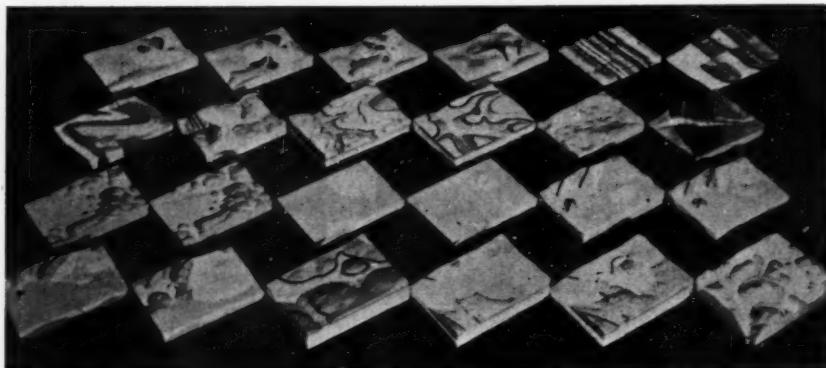
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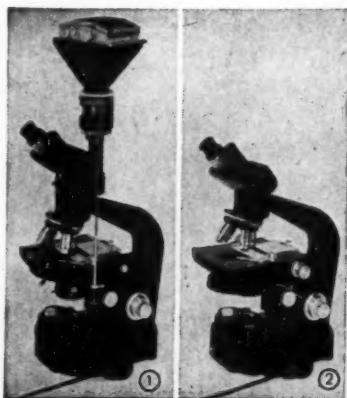
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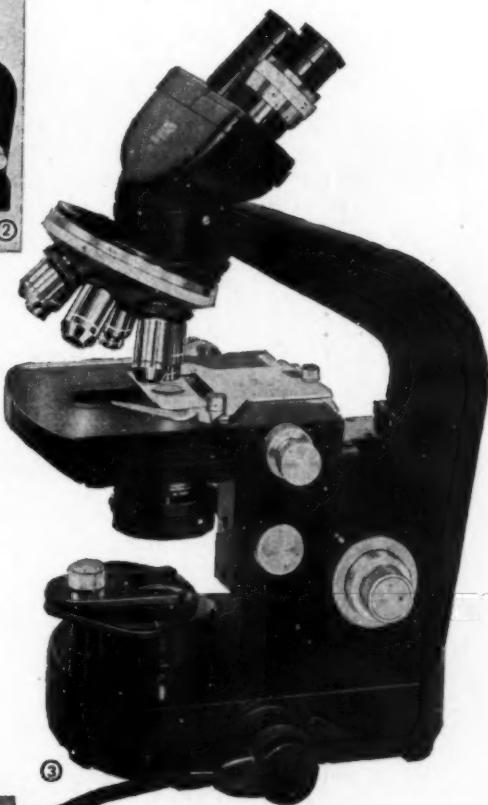
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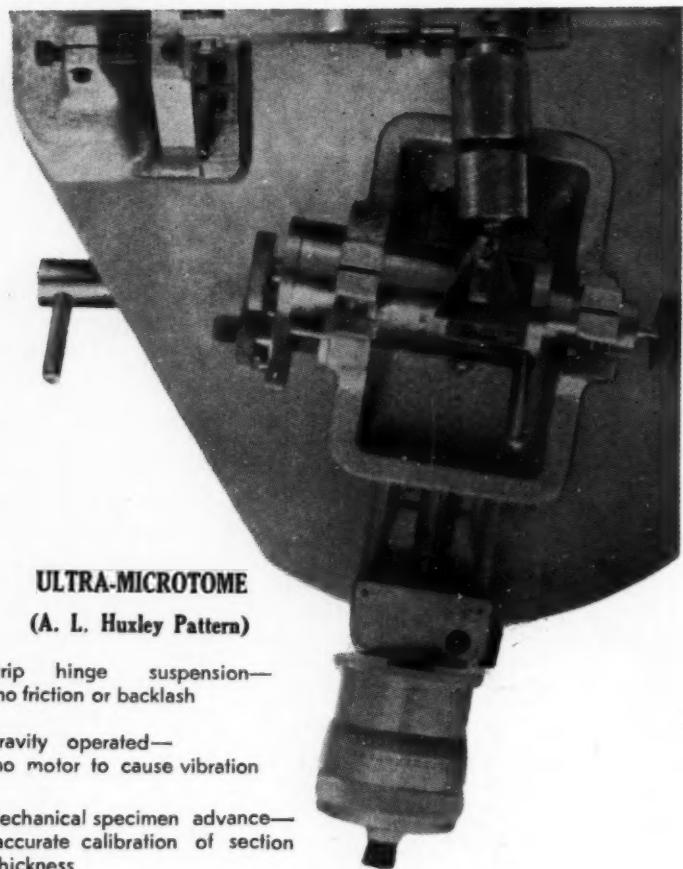
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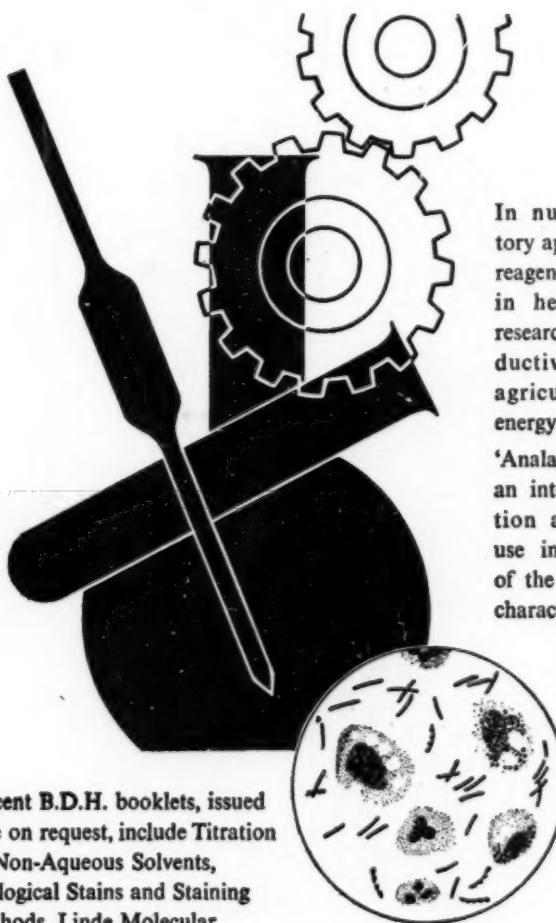
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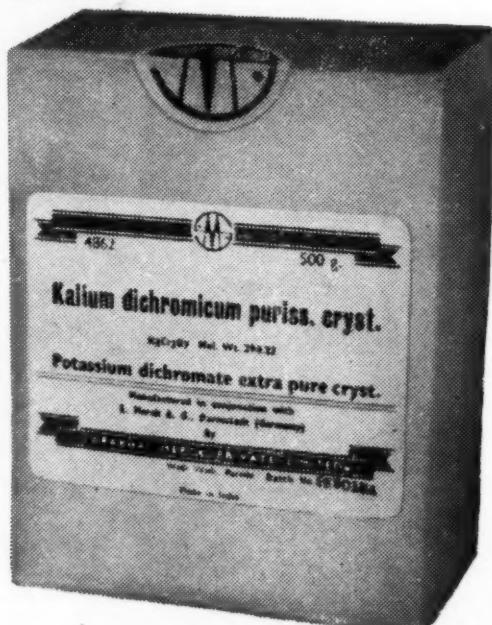
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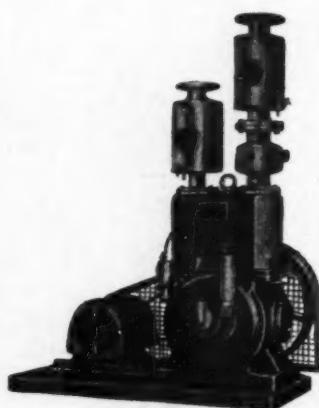
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STRUCTURE OF COLLAGEN

G. N. RAMACHANDRAN AND V. SASISEKHARAN

Department of Physics, University of Madras, Madras-25

A TRIPLE helical structure for collagen was proposed from this laboratory more than six years ago.¹ This consisted of three polypeptide chains, each having a three-fold screw symmetry (3_2 for L-type residues) which were linked together by hydrogen bonds approximately perpendicular to the length of the chains. A very satisfactory feature of this structure was that every third residue in it must necessarily be a glycyl residue, for there was no space in it for a side group (or even the β -carbon atom⁴) to be attached to the corresponding α -carbon atom. This particular feature, namely, that 33% of the residues are glycyl, is universally true of collagen from different sources. The structure could readily accommodate proline and hydroxyproline residues (the latter in particular being known to be characteristic of collagen alone), besides being in agreement with the infra-red dichroism and other properties of collagen.

It soon became apparent that, although the structure was basically correct, the details required modification, for an analysis of the X-ray pattern of stretched collagen² indicated that the number of residues per turn in collagen is nearly $3\frac{1}{3}$ and not 3. The presence of such a non-integral number of residues per turn required that the three chains must all be further coiled around. Consequently, a coiled coil structure was put forward for collagen, which retained the essential features of the earlier one.³ The structure was made to have as many hydrogen bonds as possible, namely, two hydrogen bonds for every three residues, although this led to some short contacts.

This structure has however been criticized because of the occurrence of these few short contacts⁴ and it has been suggested that only structures with one hydrogen bond for every three residues can be built up which are free of short contacts. It appears to be generally taken for granted following the above-mentioned criticism of Rich and Crick⁴ that a two-bonded structure is impossible for collagen. But, as stated by Ramachandran,⁵ such an one-bonded structure is really unsatisfactory as a set of hydrogen bonds are not formed and a number of imino hydrogens are systematically left unbonded. It is possible, however, that these hydrogens may take part in bonding through a water molecule, but a careful study is required

of this question, and such a bond need be postulated only if a direct hydrogen bond is impossible.

The whole question has been re-examined recently in this laboratory, and it has been found that it is not impossible to bring the short contacts to permissible values while still retaining the two hydrogen bonds. The purpose of this communication is to show that a structure with two hydrogen bonds for every three residues is a possible one and is consistent with the physical and chemical properties of collagen.

Such a structure became possible essentially because a close study made in this laboratory of the available data on various organic structures showed that the exigencies of the situation in several cases may demand (interatomic) contact distances much shorter than the sum of the corresponding van der Waals' radii. Many examples can be cited in which the contact distances are much shorter than the criteria stated by Rich and Crick in their paper⁴ (viz., C...C = 3.6 to 4.0 Å and C...O = 3.2 to 3.5 Å). Thus an examination of the reported crystal structures shows that not only are C...C distances of the order of 3.2 Å (the value found in our earlier structure) observed in a number of cases, but that they can even be smaller, down to 2.9 Å. So also C...O contacts are found to be less than 3.1 Å in a number of cases and values down to 2.7 Å have been reported. Also, if Rich and Crick's criteria were adopted, some of the known structures, for example the α -helix, would be unacceptable. (The full data will be given in a detailed publication.)

The other criticism that has been made is that the two-bonded structure (two hydrogen bonds for every three residues) cannot accommodate the sequence gly-pro-hydro, which appears to be of frequent occurrence in hydrolysates of collagen, for at the second α -carbon atom, there is no NH now to be hydrogen bonded. However, this does not mean that one must switch over from a two-bonded to a completely one-bonded structure. It is obvious that in those regions where proline does not occur, a structure in which the imino group is bonded is preferable to one in which it is not. In our latest approach both hydrogen bonds are made, but where the sequence gly-pro-hydro occurs, the residues slightly rotate around to accommodate these side-chains.

Another factor which helped in working out a satisfactory two-bonded structure is that an examination of the known structures of amino-acids and peptides revealed appreciable deviations either from planarity of the peptide group or from the standard bond lengths and bond angles in the group in almost every case. Obviously, such variations occur because the situation demands it, e.g., some hydrogen bond is made shorter or more straight thereby, or somewhere a short contact is relieved. This suggests that provided the structure proposed has values for the bond distances and angles within the observed range in various known crystal structures, it should be considered satisfactory. In the latest structure, whose co-ordinates are given below, small deviations of the peptide groups from planarity occur, but the bond lengths and angles are all well within the normally observed range.

Another interesting factor revealed by a survey of the literature which helped in working out the two-bonded structure was that the hydrogen bond distance from an amide NH to a carbonyl oxygen ($O = C$) is invariably larger than 2.9 Å. It is found that for hydrogen bond distances lying between 3.0–3.05 Å, the infra-red frequency is about $3,350 \text{ cm}^{-1}$ which is nearly the same as found in collagen (actually for collagen it is close to $3,330 \text{ cm}^{-1}$). This is rather important, since it is found very difficult to reduce the bond lengths to less than 3.0 Å in the two-bonded structure. On the other hand, it is, in the one-bonded structure, rather difficult to increase the bond length to greater than 2.85 Å if the condition that every third residue should be glycine is assumed. Thus infra-red data show that most of the hydrogen bonds in collagen are weaker than in other proteins and polypeptides and this is in good agreement with the two-bonded structure.

One of the main results of our present study is that, while the two-bonded structure is highly specific and can only occur for helical parameters close to what are actually found in collagen, the one-bonded structure can occur over a very wide range of configurations. Also, a fact which seems to have been overlooked previously is that there is no reason why the exact rational value $10/3$ should occur for the number of residues per turn (n) in the minor helix. In view of this, following Rama-chandran's paper,⁶ careful measurements were made on X-ray patterns of both natural and stretched collagen and these showed that the value of n is close to 3.28 and not 3.33 ($10/3$), i.e., the twist for three residues t is only about

30° and not 36° , as has been assumed so far. In addition it was also found that the residue height h for unstretched collagen is 2.95 Å rather than 2.86 Å. These values, viz., $h = 2.95 \text{ Å}$, $n = 3.28$, $t = 30^\circ$ should replace the older values $h = 2.86 \text{ Å}$, $n = 3.33$, $t = 36^\circ$.

These changes are really significant from the point of view of the stereochemistry of the structure, for it is actually found that a two-bonded structure based on the new values is superior to the one based on the old values with respect to short contacts and hydrogen bond angles.

A projection of the new two-bonded structure, the so-called standard structure, arrived at after a careful study, is shown in Fig. 1 and the co-

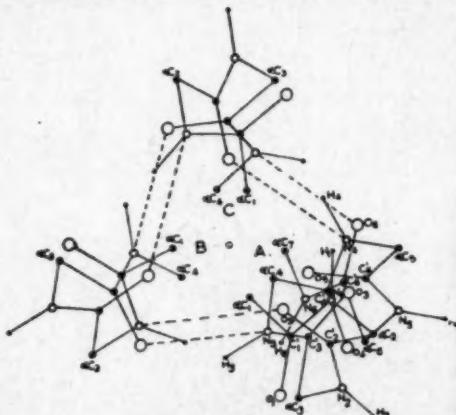


FIG. 1. Projection of the standard structure of collagen along the fibre axis. The two hydrogen bonds, for every three residues are shown by dotted lines.

ordinates are given in Table I. The interatomic distances and bond angles for this structure are not significantly different from the Pauling-Corey parameters. The two hydrogen bond lengths, viz., $N_1H_1(B) \dots O_2(A) = 3.00 \text{ Å}$ and $N_3H_3(A) \dots O_2(B) = 3.05 \text{ Å}$ are agreeing well with the infra-red data and the angle between NH and NO is less than 30° for both the bonds. The only short contacts found in the structure are (1) $O_2(A) \dots O_3(A) = 2.73 \text{ Å}$, (2) $C_1(B) \dots O_2(A) = 2.90 \text{ Å}$, (3) $C_4(A) \dots O_2(B) = 3.10 \text{ Å}$, (4) $C_4(A) \dots O_3(B) = 3.03 \text{ Å}$, and (5) $C_1(A) \dots C_1(B) = 3.50 \text{ Å}$. The structure is thus seen to be satisfactory in every respect.

The satisfactory nature of this structure explains the occurrence of $h = 2.95 \text{ Å}$ in natural collagen which is found to be remarkably constant in specimens from a wide variety of sources.

TABLE I

Atomic co-ordinates of the atoms in one set of three residues of the proposed structure of collagen. The cylindrical polar co-ordinates given are with respect to the axis of the major helix

Atom	<i>r</i> (Å)	(°)	<i>s</i> (Å)
C ₁	1.15	0.0	0.00
C _{1'}	2.27	12.0	1.00
O ₁	3.26	-3.6	1.15
N ₁	2.43	38.8	1.70
H ₁	2.15	63.1	1.71
C ₂	3.52	35.4	2.72
C _{2'}	2.93	23.0	3.96
O ₂	1.75	17.5	4.16
N ₂	3.79	15.8	4.82
H ₂	4.78	18.1	4.70
C ₃	3.47	2.0	6.00
C _{3'}	2.50	18.7	6.86
O ₃	2.68	45.5	6.50
N ₃	1.95	1.8	7.87
H ₃	2.29	-24.4	8.04
C ₄	1.15	30.0	8.85

So also attempts were made to build structures corresponding to twists *t* of 10° and 50° for three residues keeping *h* = 2.95 Å, but these were distinctly bad since one of the hydrogen bonds became very long when short contacts were avoided. This explains why collagen forms a coiled coil structure, and also why the coiling corresponds to a twist close to 30° for three residues.

On the other hand for an one-bonded structure which can occur over a very wide range of configurations, no coiled coiling is needed and the residue height can also vary. It is not specific and it cannot explain why collagen has the parameters for its structure which are actually found.

Thus, in short, the two-bonded structure could explain several of the observed facts about collagen such as

(a) The observed height of about 2.95 Å per residue along the fibre axis and its relative inextensibility; (b) the occurrence of a coiled coil instead of a simple triple chain and the actual magnitude of the second coiling and

TABLE II

The co-ordinates of the atoms in a set of three residues of the three chains A, B₁ and B₂ of the structure of collagen. For the chain A which accommodates the sequence gly-pro-hydroxypro, the co-ordinates of the side chain atoms of the proline and hydroxyproline residues are also given. The co-ordinates given are with respect to the axis of the major helix

Atom	<i>r</i> (Å)	(°)	<i>s</i> (Å)	Atom	<i>r</i> (Å)	(°)	<i>s</i> (Å)
Chain A							
aC ₂	1.15	80.0	-2.95	C' ₂	2.93	23.0	3.96
C ₋₂	2.19	84.7	-1.83	O ₂	1.75	17.5	4.16
O ₋₂	2.90	64.8	-1.38	N ₂	3.79	15.8	4.82
N ₋₂	2.69	112.0	-1.41	H ₂	4.78	18.1	4.70
βC ₋₂	3.12	139.1	-1.81	aC ₃	3.47	2.0	6.00
γC ₋₂	4.58	136.9	-1.37	C' ₃	2.50	18.7	6.86
βC ₋₂	4.65	125.5	-0.14	O ₃	2.68	45.5	6.50
aC ₋₁	3.71	109.1	-0.33	N ₃	1.95	1.8	7.87
C ₋₁	2.99	99.1	0.89	H ₃	2.29	-24.4	8.04
O ₋₁	1.77	97.8	1.05	aC ₄	1.15	30.0	8.85
N ₋₁	3.83	93.5	1.83	Chain B₁—(Contd.)			
βC ₋₁	5.28	95.2	1.80	aC ₂	3.47	-133.0	0.10
γC ₋₁	5.87	85.0	2.78	C ₀	2.50	-121.3	0.96
O ₀	6.28	72.8	2.09	O ₀	2.68	-94.5	0.60
βC ₋₁	4.90	81.0	3.78	N ₀	1.95	-138.2	1.97
aC ₀	3.46	82.0	3.05	H ₀	2.29	-164.4	2.14
C' ₀	2.50	88.7	3.91	aC ₁	1.15	-110.0	2.95
O ₀	2.68	125.5	3.55	C ₁	2.27	-98.0	3.95
N ₀	1.95	81.8	4.92	O ₁	3.26	-113.6	4.10
H ₀	2.29	55.6	5.09	N ₁	2.43	-71.2	4.65
aC ₁	1.15	110.0	5.90	H ₁	2.15	-46.9	4.66
Chain B₂							
aC ₂	1.15	0.0	0.00	aC ₂	3.52	-74.6	5.67
C ₂	2.27	12.0	1.00	C ₂	2.93	-87.0	6.94
O ₁	3.26	-3.6	1.15	O ₂	1.74	-91.0	7.14
N ₁	2.43	38.8	1.70	N ₂	3.78	-94.8	7.77
H ₁	2.15	63.1	1.71	H ₂	4.76	-92.5	7.65
aC ₂	3.52	35.4	2.72	aC ₃	3.47	-108.0	8.95

(c) the occurrence of 33% of glycine and a large proportion of proline and hydroxyproline.

The one-bonded structure cannot explain any of these properties except (c) since a wide range is possible for it. The infra-red data also completely support the occurrence of long hydrogen bonds 3.0–3.05 Å, found in the two-bonded structure.

Even when the sequence gly-pro-hydroxyproline occurs in one of the three chains, or locally in all the three chains, the standard structure can be slightly modified to incorporate these. The coordinates of the atoms in the three chains in the former case are given in Table II and the structure is shown in Fig. 2. Five hydrogen

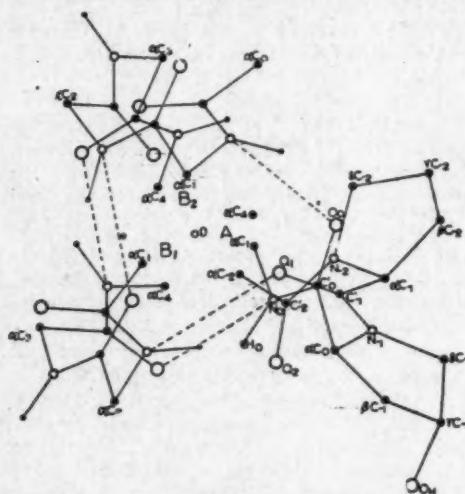


FIG. 2. Projection along the fibre axis of the structure of collagen with five hydrogen bonds for nine residues. For the chain 'A' which accommodates the sequence gly-pro-hydroxyproline, the positions of all the atoms of the proline and hydroxyproline residues in the projection are also shown.

bonds are formed for every nine residues. The atoms in two backbones of the chains are practically in the same positions as in the standard structure, while in the third chain none of them are displaced by more than 0.5 Å. If all the

three chains have the sequence gly-pro-hydroxyproline, then only an one-bonded structure is possible, but even in this case, the shifts of individual atoms are less than 0.5 Å.

Finally it may be mentioned that the calculated Fourier transform (F.T.) of the standard two-bonded structure is in good agreement with observation. Also, the two-bonded structure is distinctly in better agreement with the observed X-ray pattern than the one-bonded structure. Thus, its F.T. has a broad belt of intensity centred at $\xi = 0.35$, as actually observed, while this belt is distinctly nearer the meridian ($\xi = 0.30$) for the one-bonded structure. So also, the first maximum on the third layer is much stronger with the two-bonded structure, as actually observed. The position of the first maximum on the fourth layer is closer to the meridian for the two-bonded structure and occurs close to the observed position. In the sixth layer, there is a clear maximum in the F.T. at $\xi = 0.66$, as observed for this structure, while there is no such maximum in the F.T. of the one-bonded structure. Lastly, the strong blob of intensity observed on the equator corresponding to $d = 4.4$ Å is explained by the occurrence of nearly parallel planar residues in the backbones of neighbouring chains at this distance apart. The corresponding distance in the one-bonded structure is 4.8 to 4.9 Å, and does not agree with observation.

Details of these studies are given in a series of papers in the Report of the Collagen Symposium held at Madras in November 1960 (under publication). We wish to acknowledge the assistance of Messrs. Y. T. Thathachari, B. R. Lakshmanan and C. Ramakrishnan in part of this work.

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LONG WAVELENGTH SPECTRUM OF SOLAR CORONA

A SPECTRUM of the solar corona in the near infra-red region 1μ , was obtained by the staff members of the Sternberg Institute of Astronomy, USSR, during the solar eclipse of February 15, 1961. A detailed study of the emission line of wavelength 1.0747 micron (10747 Å) has been made in this region. This

line is emitted by strongly ionized atoms of iron which have 12 electrons knocked out of them under extremely high temperature. It is reported that the obtained information warrants definite conclusions concerning the physical conditions of matter in the outer envelope of the solar atmosphere.—(USSR News).

MORPHOGENETIC RESPONSES OF THE THALLUS OF *MARCHANTIA NEPALENSIS* L. ET L. TO SEVERAL GROWTH SUBSTANCES

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DURING recent investigations on the reactivity of young developing thalli of *Marchantia nepalensis* L. et L. to several growth substances we found that the different organs of the thallus responded differently to different growth substances.

Aseptic cultures were prepared from young thalli of about 1.0 cm. in length as inocula on a standard Knop's nutrient solution with the addition of three concentrations, namely, 1.0, 0.1 and 0.01 mg./l. of Indoleacetic acid (IAA), Indolebutyric acid (IBA), Indolepropionic acid (IPA), α -Naphthaleneacetic acid (NAA), Naphthoxyacetic acid (NOA), 2, 4-Dichlorophenoxyacetic acid (2, 4-D), Maleic hydrazide (MH), 2:4:5: Trichlorophenoxyacetic acid (TCPA), 2:3:5: Triiodobenzoic acid (TIBA), and 2, 4-Dinitrophenol (2, 4-DNP). Both solid and liquid cultures were grown under artificial light from fluorescent tubes (Natural) giving 2,600-3,000 lux of 17 hours duration in 24 hours cycle at the level of the cultures. The temperature was regulated at 24°-25° C.

The most striking effects may be summarized as follows :

(a) Highest concentration (1.0 mg./l.) of NOA, 2, 4-D, TCPA, IPA, IAA and IBA and 0.1 mg./l. of NAA stimulated rhizoid formation and inhibited thallus growth but NAA in its highest concn. was inhibitory to rhizoid formation. Furthermore NAA, NOA and TCPA induced rhizoid formation not only on ventral but also on dorsal surfaces of thalli extending up to their apical regions. The latter substances including 2, 4-D in their lowest concn. (0.01 mg./l.) was even inhibitory to thallus growth.

Highest concn. of MH, TIBA and 2, 4-DNP neither stimulated nor inhibited rhizoid formation and thallus growth and even their lower concns. (0.1 and 0.01 mg./l.) were not stimulatory to either rhizoid formation or to thallus growth.

(b) Highest concn. of NAA, NOA, TCPA and 2, 4-D produced globular masses of callus-like tissue on inoculated thalli. The globular masses were mostly yellowish-brown or brown in colour except those produced by TCPA which were green. Even at a later period of growth the globular masses did not differentiate into thalli but they did so on being transferred to

control media. However, these differentiated thalli did not attain normal size (Fig. 1 A).

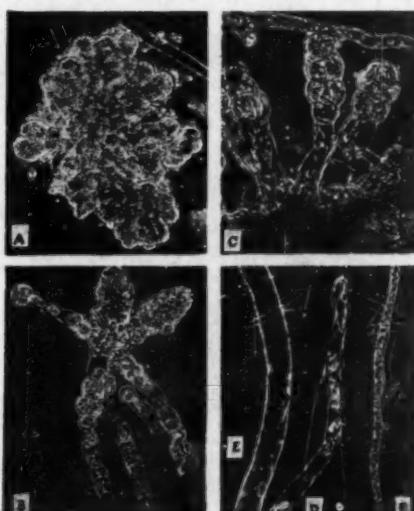


FIG. 1. *Marchantia nepalensis*. A, Callus like growth, $\times 75$; B and C, filamentous growth terminated by differentiating thalli—B $\times 55$, C, $\times 90$; D A tuberculated rhizoid ($\times 140$) showing pegs in its distal region but not in its terminal portion; E, Tip region of the tuberculated rhizoid shown in D, $\times 140$; F, a tuberculated rhizoid ($\times 50$) showing prominent pegs.

(c) Highest concn. of IAA, IBA, IPA, TIBA and 2, 4-DNP produced globular masses of callus-like tissue on inoculated thalli at an earlier period of growth but at a later period these masses differentiated into new thalli. Whereas highest concn. of MH and TIBA produced new thalli directly from inoculated thalli.

Commonly new thalli were minute and brittle in liquid cultures.

(d) New thalli developed in three ways : (i) directly from cells of inoculated thalli commonly from their distal regions ; (ii) from cells of globular masses ; and (iii) from filamentous growth of cells of inoculated thalli and of globular masses (Fig. 1 B, C).

(e) All the concns. of IPA, TIBA, 2, 4-D and 2, 4-DNP inhibited typical tuberculate rhizoid formation in their liquid but not in their solid cultures ; but only in one case, that of 1.0 mg./l.

NAA, tuberculate rhizoids were not formed in liquid as well as in solid cultures.

Pegs of tuberculate rhizoids were poorly developed in liquid cultures containing 1·0 and 0·1 mg./l. of TCPA, IAA, NOA and IBA and even in control liquid cultures (Fig. 1 D, E, F).

(f) Highest concn. of NAA, NOA, TCPA and 2, 4-D and 0·1 mg./l. TCPA inhibited gemma-cup formation in solid as well as in their liquid cultures.

Highest concn. of IPA, IBA and TIBA and 0·1 mg./l. NOA inhibited gemma-cup formation in their solid cultures only. In solid cultures gemma-cups were formed mostly in submerged thalli but very rarely in aerial ones.

Gemma-cup formation was markedly pronounced especially in liquid cultures containing 2, 4-DNP and TIBA.

(g) Germinated gemmæ with smooth rhizoids were found within gemma-cups in cultures containing MH, NAA, NOA, 2, 4-D and 2, 4-DNP and also in control cultures.

Germinated gemmæ without rhizoids were found within gemma-cups in cultures containing MH, NAA, NOA, 2, 4-D and 2, 4-DNP and also in control cultures.

It is evident from the observations mentioned above that rhizoids and thalli of *Marchantia nepalensis* like roots and shoot-buds of higher plants responded in a similar way to stimulatory and inhibitory effects of higher and lower concns. of auxins and antiauxins used. It may thus be envisaged that there exists a basic biochemical pattern common to roots and shoot-buds of higher plants and rhizoids and thalli of *M. nepalensis* indicating homologies in organization. In higher plants this basic biochemical pattern has further been elaborated during evolution giving rise to more complex organizations like roots and shoot-buds.

The antiauxins like MH, TIBA and 2, 4-DNP are well known for their peculiar effects in higher plants but they have not produced any such effects in the highest concn. used in this experiment. It is to be seen whether they can produce any morphogenetic response in still higher concns.

Allsopp¹ obtained callus-like tissue in *Fossombronia pusilla* (L.) Dunn. and *Reboulia hemispherica* (L.) Raddi. in cultures containing glucose. In the present experiment globular masses produced by certain auxins and antiauxins mentioned previously are similar undifferentiated callus-like tissue which begins to differentiate when transferred to nutrient media without the growth substances. According to Bunning^{2,3} polarity is of decisive importance for

all the processes of differentiation, and suppression of polarity by direct effects of physical or chemical factors on the protoplasm, will prevent normal differentiation but may allow cell division to continue. On the basis of this hypothesis, the action of these growth substances on young developing thalli could be due to their direct effect on the internal gradients of chemicals.

Regeneration of thalli directly from cells of inoculated thalli or from filamentous growth of cells of inoculated thalli or of globular masses throws light on the debated problem of the existence of hepaticas. Various lengths of filamentous growth observed in the present experiment prior to the differentiation of a normal thallus from a two-sided apical cell indicate that the filamentous growth results from induction of successive transverse divisions in the thallus initial by different growth substances for a variable duration. Similar prolongation of thallus initials into filamentous growth prior to differentiation by a physical factor like unilateral or weak illumination has been reported by Goebel,⁴ Pande,⁵ Mehra and Kachroo⁶ and others in other hepaticas. This filamentous growth is not comparable to protonemal growth of mosses where it is a distinct and a constant phase of the gametophyte. These experimental evidences support Campbell's⁷ conclusion on this issue.

Inhibition of tuberculate rhizoids and not of smooth ones by certain growth substances and the formation of tuberculate rhizoids with various degrees of poorly developed pegs in cultures containing certain growth substances bring out that the two types of rhizoids are not only morphologically but also physiologically different. This point is emphasized by the occurrence in cultures of certain tuberculate rhizoids whose distal regions are with poorly developed pegs but their terminal regions are without them. Furthermore the presence of poorly developed pegs in tuberculate rhizoids of control liquid and not of control solid cultures indicates that the hydration of the colloidal constituents of the cell may have affected synthesis of peg substance which seems to be pecto-cellulose on micro-chemical tests. Synthesis of peg-substance was completely inhibited in liquid but not in solid cultures containing certain growth substances as mentioned previously. This finding tends to help in the understanding of the speculated functions of the two types of rhizoids of the Marchantiaceae. We are also well aware of the morphogenetic effects of water in higher plants as well expressed by the phenomenon of heterophyly and the production of

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land and water forms of certain amphibious plants.

LaRue and Narayanaswami⁸ state that the gemmae of liverworts do not germinate within gemma-cups unless they have been detached from the parent body. Audus⁹ suggests that "in this the controlling agent may be a specific inhibitor produced by the parent tissue". In the present experimental conditions germinated gemmae with or without rhizoids have been found within gemma-cups in control cultures as well as in cultures containing certain growth substances. It is also interesting to note that certain growth substances have inhibited the formation of gemma-cups. The findings also indicate that production of gemma-cups is conditioned by good humid conditions.

These observations will be considered in greater detail elsewhere.

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RESEARCH INTO BOILER CIRCULATION THEORY

A REPORT on an extensive series of experimental investigations of the fundamental factors influencing the circulation process in high pressure boilers was presented to a meeting of the Institution of Mechanical Engineers in London, on 29th March 1961, by Haywood, Knights, Middleton and Thom.

The research project was sponsored by the Water-Tube Boilermakers' Association and was carried out by the authors at Cambridge. The primary object of the research was to establish experimental data relating to the flow conditions and pressure drop of high pressure steam-water mixtures flowing along heated and unheated pipes—in both horizontal and vertical positions. Simple boiler circulation theory is based on the assumption that the steam-water mixture moves as a homogeneous fluid, but there was little existing data on effects of relative velocity between the steam and water phases, a phenomenon which was known to exist under actual flow conditions in a boiler circuit. The paper describes an isotopic technique of determining this relative velocity of the two phases.

This consists in measuring the absorption of gamma-rays in their passage through the two-phase mixture at the outlet from the test section. The results from the gamma-ray equipment—in which the beam was provided by a radioactive isotope of caesium—enabled calculations to be made of the apparent density of the fluid mixture, and consequently the respective velocities of the two phases at that point. Preliminary tests involving scans along a number of chords of the tube cross-section showed that the density distribution of the fluid

was different with horizontal and vertical pipes. The data thus obtained from these and other tests were used to calculate slip correction factors, by means of which the acceleration and gravitational pressure drops—calculated according to homogeneous theory—could be corrected for the effects of slip. The paper presents an analysis of the pressure drop measurements made on the 1-inch and 1½-inch bore pipes in the vertical and horizontal positions, with particular attention to the frictional pressure drops in the horizontal pipes.

In their conclusions the authors state that, over the range of variables covered in the tests, the experimental pressure drops at 2,100 p.s.i. abs. are close to the values predicted by homogeneous theory for both horizontal and vertical pipes. For horizontal pipes at the lower pressure, homogeneous theory gives closer prediction of the pressure drop for heated than for unheated pipes, owing to the opposing effects of two-phase flow conditions on the frictional and acceleration pressure drops in the heated pipes. For vertical pipes at the lower pressures, the experimental pressure drops are significantly greater than the values predicted by homogeneous theory. The gravitational contribution to the total pressure drop is dominant, and it is influenced significantly by the effects of slip.

The results of the work have provided a wealth of information in a field in which there has been previously a scarcity of reliable data.—(Courtesy: The Water-Tube Boilermakers' Association, 8 Waterloo Place, London, S.W. 1).

SOME NEW CONCEPTS IN NON-LINEAR SYSTEMS

C. LAKSHMI-BAI*

OF late active interest has been displayed in the general field of non-linear systems and various techniques have been developed to analyse different aspects of the system under investigation. A technique developed by the author giving a new perspective and greater insight into the physical significance of the response of non-linear systems is presented in this communication.

Its principal features, and the major conclusions arrived at, are indicated in brief.

The behaviour of many complex physical systems is governed by higher-order non-linear differential equations. The solution of such equations is closely related to the number and nature of roots of the associated linear differential equation. The solution of the governing equation itself, is here obtained by the principle of the variation of parameters. It has been recognized that any non-linear system can be easily portrayed by a simple mathematical representation by means of a 'response-vector' and an orthogonal frame of reference. This reference-frame can have its directions along the inphase, quadrature and zero-phase components, with reference to the phase of the assumed solution. Thus, it can be easily visualized that the response-vector belongs to a space of as many dimensions as the order of the original governing equation; and, that it can be resolved into components along the above-referred directions of remarkable physical significance. These can be suitably denoted by the term 'space-phase components'.

One of the important features of the mathematical representation is that cross-harmonic terms are no longer present, yet the non-linear behaviour has been adequately accounted for by the d.c. and first harmonic terms. Thus it can be significantly referred to as the 'transient system-equivalent'. Such a representation can take care of the different types of inputs along with specified initial conditions. Thus it can reveal valuable information about peak overshoot, time of rise, time of settling, as well as possible limit-cycle behaviour. Though geometric representation is possible only for first, second and third order systems, the analysis itself is not limited by the order of the equation, and the principles can be ex-

tended to higher-order systems, with suitable engineering judgment.

It is further observed, that the zero-phase component influences only the amplitude of the response, while the inphase and quadrature components modify the amplitude, as well as the frequency of the response. Thus it is seen that these new concepts isolate important characteristics into quantities which represent a better criterion of the controlling factors. This feature is of great help in the synthesis procedures.

Another important feature of this technique is its striking analogy to the classic technique of symmetrical components. The more important of the analogues are indicated in Table I, while Table II shows the main points of difference.

The technique has been applied to evaluate the transient response of a multiplicative feedback control system.¹ The instantaneous error of the system to unit step input is governed by the equation

$$\frac{d^3e}{dt^3} + \frac{d^2e}{dt^2} + \left(1 - \frac{1}{2}e^2\right) \frac{de}{dt} + \frac{1}{2}e = 0. \quad (1)$$

The initial conditions of the error are given by

$$e(0) = 0.5, e'(0) = 0 \text{ and } e''(0) = 0. \quad (2)$$

The solution of the above non-linear equation is obtained by the principle of variation of parameters; and is given in equation (3).

$$e(t) = -\frac{1}{6}e^{-2t} \sin\left(t + \frac{\pi}{2}\right) + \frac{2}{3}e^{-t/2}. \quad (3)$$

Thus, the transient response of the system for unit step input is given by

$$C(t) = 1 + \frac{1}{6}e^{-2t} \sin\left(t + \frac{\pi}{2}\right) - \frac{2}{3}e^{-t/2}. \quad (4)$$

In equation (4), $C(t)$ is the response-vector, $1 - (2/3)e^{-t/2}$ is the zero-phase component, which modifies only the amplitude of the response, while $(1/6)e^{-2t} \sin(t + \pi/2)$ is the inphase component which modifies both the amplitude and the frequency of the response. The quadrature component is zero.

Equation (4), derived analytically, shows very favourable agreement with the analogue computer study as given in ref. 1.

It is believed that this technique will lead to further developments in the theory, and application to non-linear control systems, possibly even for random inputs.

The detailed paper will be published elsewhere.²

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TABLE I
Analogues

Symmetrical components		Space-phase components
1 Number of phases of the electrical system	..	Order of the governing equation
2 Unbalance effects	..	Non-linear effects
3 Mutual coupling between phases due to dis-symmetry	..	Presence of cross-harmonic terms
4 Positive and negative sequence components	..	Inphase and quadrature components
5 Zero-sequence component	..	Zero phase component
6 A simple mathematical representation of an unbalanced electrical system	..	A simple mathematical representation of a non-linear physical system
7 Enables stability study of power systems	..	Enables stability study of physical systems governed by the non-linear differential equation
8 Valid for analysis of transient as well as steady state behaviour (transient analysis by using Lyon's approach)	..	Valid for analysis of transient as well as steady state behaviour
9 Various time constants of the system can be determined	..	Time of rise, time of settling and other relevant time constants can be determined
10 Initial currents or voltages can be accounted for	..	Initial conditions can be accounted for
11 Suitable for study of transient disturbances and fault conditions	..	Any type of input in closed form can be studied, and instruments can be devised to control extraneous disturbances
12 Grounding phenomena associated with zero sequence component	..	Zero-phase component influences only the amplitude of the response, while the inphase and quadrature components influence both the amplitude and the frequency

TABLE II
Differences

Symmetrical components		Space-phase components
1 Linearity is assumed in the derivation of the equivalent representation	..	The only assumption made is that higher harmonics in the response of the non-linear component are adequately filtered out by the linear part. This assumption is quite valid and practical with non-linear control systems
2 Sequence currents, voltages and impedances	..	The only variable is the system response
3 Evaluation of sub-transient parameters	..	None
4 Synthesis of networks to represent faults	..	Synthesis of components to represent non-linear effects is not possible because of the assumption made
5 Special features in the application to rotating machines	..	No essential difference in application to static and dynamic non-linear components
6 Sequence components are coplanar for any number of phases	..	Phase-space components are mutually orthogonal and located in space

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ALPHA-ACTIVITY OF DRINKING WATERS OF BRITAIN

INVESTIGATION of the nature and levels of naturally occurring radioactivity in human foods and potable waters is of vital interest. Prof. Mayneord of the Institute of Cancer Research, London, has reported the results of experiments on the α -activity of drinking waters supplied to the population of Britain. (In passing it may be noted that as early as 1902, J. J. Thomson made observations on the radioactivity of Cambridge water).

Mayneord and his collaborators have measured the radium-226 content of 71 drinking waters of Britain. The water samples were collected from several points of view, including the size-

of population supplied, and the nature of the associated geological formations. The samples can be divided broadly into five types, namely, (A) Spa waters which possess high contents of mineral matter; (B) Waters of Cornwall parts of which county are known to have deposits of uranium and radium; (C) Ground waters from boreholes in geological strata other than chalk; (D) Ground waters from boreholes in chalk, and (E) Surface waters from rivers, lakes and reservoirs.

In the experimental procedure, a litre of each specimen of water was evaporated to dryness and the α -activity of the residue measured

using an α -ray counting technique. Measurements were made on each specimen of residue immediately after evaporation and at intervals of a few days during the following 30 days, by which time the radon-222 and its α -emitting daughters Ra-A, and Ra-C' would have reached equilibrium with the radium-226 present. After 30 days no further change could be detected in any of the specimens.

The mean α -activities, in $\mu\text{c}/\text{litre}$, of the various groups are as given below. The solid residue in parts per million and the α -activity, in $\mu\text{c}/\text{gm.}$, of the residue are shown in brackets.

(A) Spa waters : 25.1 (2500, 14.6); (B) Cornish waters : 2.2 (90, 28.4); (C) Borehole waters (not chalk strata) : 1.4 (400, 3.7); (D) Borehole waters (in chalk) : 0.34 (200, 1.5); (E) Surface waters : 0.18 (100, 3.2).

It may be pointed out that in considering the exposure of large populations in relation to somatic effects, the maximum permissible level for soluble radium-226 in water suggested by the International Commission on Radio-logical Protection is 3.3 $\mu\text{c}/\text{litre}$.—(*Nature*, 1961, 189, 348).

RUSSIA SENDS FIRST MAN INTO SPACE

AN epoch-making success in space science was achieved by Russia on April 12, 1961, when she launched the first man into space and brought him back alive and well. The satellite space ship was called "Vostok" (the East) and the first cosmonaut who safely travelled in it and landed back on earth was Flight Major Yuri Alexeyevich Gagarin, a citizen of the USSR.

The launching of the multi-stage space rocket at 9.07 Moscow time on April 12, 1961, was successful and after attaining the first escape velocity and the separation of the last stage of the carrier-rocket the space ship went into free flight on an orbit around the earth.

The period of revolution of the satellite space ship around the earth was 89 minutes 6 seconds. The minimum distance from the earth (at perigee) was 175 kilometres and the maximum (at apogee) was 302 kilometres. The angle of inclination of the orbit plane to the equator was 65 degrees 4 minutes.

The space ship with the navigator weighed 4,725 kilograms, excluding the weight of the final stage of the carrier rocket.

Bilateral radio communications were maintained with the space navigator. The frequencies of the short wave transmitters on board were 9.019 megahertz and 20.006 megahertz and in the ultra short wave range 143.625 megahertz. The condition of the navigator in flight was observed by means of radio telemetric and television systems.

According to reports received from board of "Vostok" space ship at 9.22 Moscow time, Major Gagarin, while over South America, reported "flight is proceeding normally, I feel well". Later, when over Africa 10.15 Moscow time Gagarin reported that he was withstanding the state of weightlessness well.

At 10.25 Moscow time Gagarin began his descent to the Soviet Union. He landed in a pre-determined area at 10.55 Moscow time. He was in space for 108 minutes. This means he made just over one orbit of the earth.

Academician Blagonravov said that the first astronaut "participated to a certain degree" in his return to the earth. He was fully conversant with the use of the equipment in the space ship, "even to make small repairs if necessary" during the flight.

The successful recovery of a space ship demands precision control of the ship during flight and landing. At a definite moment the orbital space ship receives the command from earth to separate the part remaining in orbit and to start the descent. It leaves the orbit and starts on a new trajectory. Naturally, the place of landing cannot be arbitrary, therefore it is necessary to select the right time for switching on the braking engines and most accurately take into account the ship's actual speed and its position in orbit. If the mistake in determining the speed amounts to only one metre per second and the error in determining the altitude is equal to one kilometre, then the ship will deviate from the planned point of landing by dozens of kilometres.

The entire landing operation demands the extraordinarily smooth and precise work of many mechanisms, a most careful account of the actual movement of the ship and timely command from earth.

It will be recalled that the first step leading towards the present achievement was taken on October 4, 1957, when Russia put into orbit the first earth satellite Sputnik I. In the three and a half years which have elapsed since then 51 space satellites have been sent, 38 by America and 13 by Russia.

LETTERS TO THE EDITOR

EXPERIMENTAL STUDY OF
TRANSITION PROBABILITIES IN
ASTRAL RADICALS: LaO (B → X)
SYSTEM

Of the few connected molecules studied for the intensity distribution, we have already reported the study of the bands of TiO and VO.¹ Another molecule in the series is LaO and it being of considerable astrophysical significance,² we give below the results of transition probabilities derived from the intensity distribution for the yellow (B → X) system of the molecule. The excitation source in this case is the carbon arc at atmospheric pressure, lanthanum oxide being packed in the lower positive carbon electrode. The technique of photographic photometry has been applied for quantitative estimation of intensities, which are taken as peak values near the band heads. These values have been utilised to arrive at the estimation of experimental transition probabilities as the ratio

$$\frac{\left(\frac{I}{v^4}\right)_{v'v''}}{\sum \frac{I}{v'^4}}$$

which could be easily deduced from the measured value of intensity I for each band. The experimental procedures have been described in detail in an earlier paper.¹ The values of experimental transition probabilities so obtained are entered in Table I.

It is expected that these results on the LaO molecule will be particularly useful to astrophysicists. With the use of these experimental transition probabilities, N. Sreedhara Murthy³ has assigned $\Delta\tau_e$, the difference in the internuclear separations of B and X levels of LaO to be 0.038 Å.

TABLE I

Band v', v''	Experimental transition probabilities	Band v', v''	Experimental transition probabilities
0, 0	0.79	2, 3	0.40
0, 1	0.21	2, 4	0.08
0, 2	0.05
1, 0	0.16	3, 1	0.07
1, 1	0.57	3, 2	0.26
1, 2	0.31	3, 3	0.27
1, 3	0.05	3, 4	0.49
2, 0	0.05	4, 2	0.06
2, 1	0.14	4, 3	0.29
2, 2	0.31	4, 4	0.10

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March 6, 1961.

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AMPEROMETRIC DETERMINATION
OF CERIUM (IV) AND Fe(III)

THE normal oxidation-reduction potential of the system Ce⁴⁺/Ce³⁺, $E_0 = 1.61$ volt depends on the acidity to a very small extent and consequently ascorbic acid can be used as a reducing agent for the quantitative determination of cerium at the rotating platinum electrode (RPE) at a potential of -0.16 to +0.56 volt versus saturated calomel electrode (SCE), when ascorbic acid does not yield an oxidation current.¹

A standard solution of ascorbic acid was preserved by the addition of formic acid. Ferric and cerium sulphate were standardised by the usual methods. Titration was carried out on the basis of the reduction current of cerium (IV) at a potential of +0.36 volt versus SCE. The experimental arrangements were as described earlier.^{1,2} The acidity of the solution has an important bearing on the experimental results and good titration results are obtained in 2.5 M sulphuric acid medium at $50 \pm 5^\circ\text{C}$, which was arrived at empirically. In higher acid solution, the oxidation-reduction potential of ascorbic acid increases and thus, its reducing action would be specific. Thereby it was possible to prevent the reduction of iron in the mixture of both; and cerium (IV) was successfully titrated under the said conditions. After completion of the reduction of cerium, corresponding to the stoichiometric reaction of this constituent, as established by a fall in the diffusion current for its reduction to zero, 8.0 M ammonium hydroxide was added to the titration mixture until a reddish-brown precipitate of ferric hydroxide appeared; which was then dissolved in 0.1 N sulphuric acid by dropwise addition of the acid. The resulting solution was heated to 60°C for about five minutes; it was cooled and adjusted to pH 1.5. The mix-

ture was then titrated again at RPE versus SCE at $50 \pm 5^\circ\text{C}$. without the appliance of an external emf against the standard ascorbic acid till the cathodic current approached zero or a constant value in the vicinity of zero. About twelve solutions of varying composition, 0.915 to 3.664 mg. cerium and 1.421 to 7.456 mg. iron present together in 25 ml., were used for the successive determinations of these elements with success. Experiments were repeated several times for good and concordant results. Graphical method was employed to determine the equivalence point of these determinations.

The results obtained for the successive determination of cerium and iron are good and satisfactory, and conditions have been established for the amperometric titrations of these elements present together in a mixture. The difference between the amount taken and found is within the experimental error, which is always less than 2.0%. It is observed that the estimations at higher dilutions yield results with greater accuracy and precision.

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December 15, 1960.

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EFFECT OF GEOLOGICAL AGEING ON THE PARTICLE SIZE OF THE BONE MINERAL

ACCORDING to the present concept the bone is built up of microcrystals which are cemented together into macroscopic particles embedded in a collagen mesh. In the present paper we report some of our data on the powder diffraction patterns of modern as well as prehistoric bones, including a specimen as old as the Lower Triassic period, which indicate changes in particle size.

The bone samples studied in this series belonged to animals. The Harappa bone was selected from this Department's collections. The older geological specimens were obtained from Geological Survey of India through the courtesy of its Director. Table I gives a fuller information of the specimens.

A fine powder of the bone sample under investigation was obtained by filing with a jeweller's file from compact part of the bone, and powder photographs were taken in a Guinier

TABLE I
Identification of the bone specimens studied by X-ray diffraction

Regd. No.	Identification	Locality	Age
..	<i>Bos indicus</i> Li. n. Pelvis	West Bengal	Modern
H.157	<i>Bos indicus</i> Met tarsal	Harappa	Chalcolithic
K8/672	<i>Bos or Bubalus</i> Metacarpal	Allahabad Ganggetic Alluvium	Pleistocene Alluvium
K13/610	Tibia of a bovid	Nila	Middle Siwaliks L. Pliocene
K47/580	<i>Dicynodon</i> <i>ori. natis</i> Humerus	Deoli	Panchet L. Triassic

Quadruple Focussing Camera with quartz monochromator, using K_α radiation.

The powder patterns were analysed by the elegant method suggested by Hessé (1948) and further extended by Stosick (1949), which has been found to be very efficient in the present studies. The mean values of the axial lengths of the hexagonal unit cell of the bone crystal calculated from our data come out as $a_0 = 9.40 \text{ \AA}$ and $c_0 = 6.88 \text{ \AA}$. These values are in close agreement with those reported by Carlstrom (1955): $a_0 = 9.412 \text{ \AA}$ and $c_0 = 6.882 \text{ \AA}$. The observed values of the spacings in the powder photographs of the different specimens are all found to agree well with the calculated values, but the lines in the photographs exhibit varying sharpness and resolution. The resolution was the highest in the L. Triassic specimen and the lowest in the modern bone. Figure 1 represents the diffraction patterns for all the five specimens mentioned above.

From the diffraction photographs it appears that 'ageing' does not bring about any crystalline structural change in the compact bone mineral. However, it appears that the crystallites gradually but very slowly gain in size in all directions within the aggregates.

Although the patterns of all the specimens agree mutually in a general way they undoubtedly exhibit certain graded differences between them. Thus, the reflection (212) and (310) are not resolved quite clearly in the Modern bone, imperfectly resolved in the Harappa bone, but in other older specimens they appear with increasing intensity and sharpness. Similarly, the triplet (321), (410) and (402) are not at all resolved but appear together as a band in the Modern as well as the Harappa bone. In the Pleistocene sample, however, the reflexion (321) is discernible as a line but the other two are not

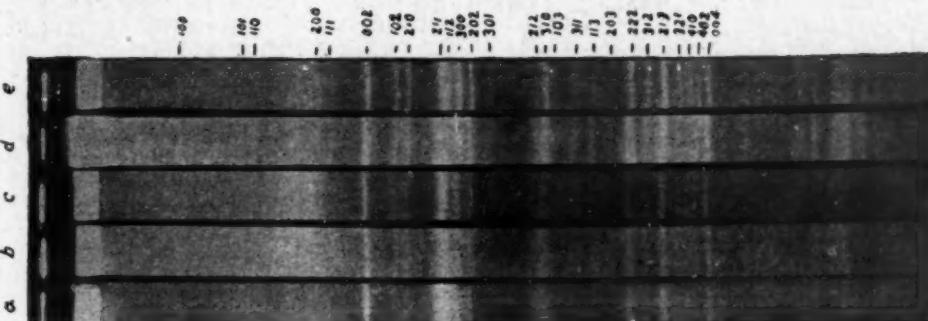


FIG. 1. Debye Scherrer patterns of bone mineral: (a) specimen of bone—Modern; (b) specimen of bone—Harappa; (c) specimen of bone—Pleistocene; (d) specimen of bone—L. Pliocene; (e) specimen of bone—I. Triassic.

separately identifiable. These lines are resolved completely in L. Pliocene. Reflexions (211) and (112) are partially resolved in L. Triassic specimens but not at all resolved in other bone samples. Again lines (102) and (210) appear with increasing sharpness and intensity from the Harappa to the L. Triassic but they are totally unidentifiable in the Modern bone. The reflexion (301) is found to be completely merged in the background in the case of the Modern bone as well as the Harappa bone, but it stands out as a clear line with increased definition in the L. Pliocene and the L. Triassic bones. The reflexion (103) appears as a faint line in the L. Triassic but not at all discernible in the other specimens. This graded difference in the definition of the reflexions may be attributed to the growth of the sizes of the crystallites, as already stated.

It would be a matter of great interest in anthropology and archaeology, if the graded characteristics of X-ray diffraction patterns of the skeletal remains briefly indicated above could fruitfully be made to yield an index for 'ageing' of the bone specimens. The number of specimens studied is, however, not large enough to prove this conclusively. Further investigations are in progress to examine this possibility.

The authors are much indebted to the Director, Geological Survey of India, for kindly supplying the bone specimens of known geological ages and to the Director, Department of Anthropology, for the facilities offered. Thanks are also due to Dr. S. C. Chakrabarty, of Allahabad University, Physics Department, for helpful discussions.

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January 30, 1961

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THROWING POWER OF LFAD NITRATE BATH FOR THE ANODIC DEPOSITION OF LEAD DIOXIDE

SEVERAL workers¹⁻⁵ have carried out investigations on the throwing power of different plating solutions commonly employed in practice and also suggested formulae for calculating the same. Recently Jelinek and David⁶ introduced a new term known as "Throwing Index" which also represents a direct measure of the throwing power of the bath. Such studies appear to have been confined mainly to plating baths, and as such for depositions on cathodes.

The present authors during their studies on the preparation of suitable lead dioxide electrodes to be used as insoluble anodes in electrolytic oxidations, found that the anodic deposition of lead dioxide could be easily carried out on graphite and/or carbon substrate^{7,8} from a bath containing lead nitrate and copper nitrate. In this deposition also, it is important to find out the capacity of the solution to give deposits even in the recesses of the anode, so that a non-porous, adherent deposit without pittings is obtained, which can effectively protect the substrate. Hence the throwing power studies for the anodic deposition of lead dioxide from lead nitrate bath was taken up.

Bath conditions employed are given in Table I. Anodes were nickel plated mild steel plates (2 cm. \times 2 cm.) attached to the sides of the cell breadthwise. The cathode was copper gauze with a copper frame (2 cm. \times 2 cm.).

The cathode was positioned according to the linear ratios desired.

TABLE I

Conditions: Cell used, 12 cm. \times 2 cm. \times 2½ cm.; volume of electrolyte 60 cc; composition of the electrolyte, 350 g./l. $Pb(NO_3)_2$ and 20 g./l. $Cu(NO_3)_2$; temperature, 30°–32°C.; pH, 4·0 at start; current passed, 0·5 amp.; Duration, 10 minutes.

Expt. No.	Linear ratio L	PbO_2 ratio M	Throwing power (%)	
			Field's formula L-M	$\times 100$ $L+M-2$
1	2	2·037	-3·2	
2	3	3·135	-3·3	
3	4	3·911	-1·5	
4	5	4·952	+0·6	
5	11	11·69	-0·45	

DISCUSSION

From the results of Table I, it is seen that the values of throwing power show a trend in that they pass through a maximum which is rather peculiar. For the determination of the throwing index, a graph was drawn taking linear ratio on the abscissa and the deposited lead dioxide ratio on the ordinate and a straight line was obtained. From this the throwing index, calculated from the reciprocal of the slope, was found to be nearly one, which is somewhat comparable to those for some of the common baths used for electroplating of metals. The determination of the throwing index could thus be made use of for the study of the effect of current density, temperature, etc., on the anodic deposition of lead dioxide as well.

The authors express their sincere thanks to Prof. K. S. G. Doss, Director of the Institute, for his keen interest and encouragement during this investigation.

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November 21, 1960.

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CONDUCTIMETRIC STUDY ON THE PRECIPITATION OF ARSENITES OF LEAD AS A FUNCTION OF THE pH

The precipitation of $NaAsO_2$ solution by $Pb(NO_3)_2$ causes the formation of complex arsenites whose composition varies with the pH. The investigations of these salts are made difficult due to the adsorption of AsO_2^- by the metal hydroxides, the easy conversion of orthoarsenite to pyro- and metaarsenite, and to the fact that these dissolve in excess of alkali or acid.¹ Consequently analytical methods have failed to give a correct view of their composition. A survey of literature reveals that the results of earlier workers^{2–6} were mainly based on the analytical investigation of the precipitates formed by mixing lead salts and alkali arsenites under different conditions and they reported the formation of several compounds of varying compositions. Besides, it appears that the formation of arsenites has not been studied at different H^+ ion concentration of the medium which plays an important role in their precipitation. Hence the present investigation has been undertaken.

The formation and composition of lead arsenite obtained by the interaction of $Pb(NO_3)_2$ and $NaAsO_2$ at definite pH levels—9·85, 11·25 and 12·28 have been studied by conductance measurements. The conductance of the solution was measured as usual by Kohlrausch Universal bridge and corrected for the dilution effect. Using different concentrations of reactants, conductimetric titrations were performed by the direct and the inverse methods.

The pH of stock solution of $NaAsO_2$ was measured by a glass electrode (range 1–13 pH) and found to be 9·85. The variations of the latter were obtained by the progressive additions of calculated quantities of $NaOH$ solutions to $NaAsO_2$. When $NaOH$ is mixed with $NaAsO_2$ in the molecular ratio 1 : 1 and 2 : 1, the corresponding compounds are $Na_4As_2O_5$ (sodium pyroarsenite) and Na_2AsO_3 (sodium orthoarsenite) and the pH of their solutions was found to be 11·25 and 12·28 respectively.

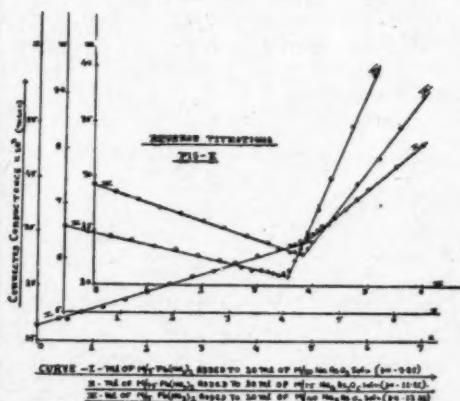
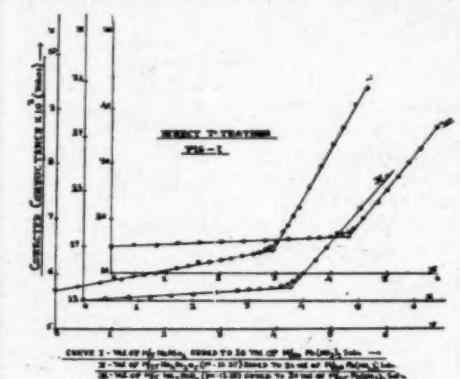
It is observed (Figs. 1 and 2) that when these alkali arsenite solutions are added to $Pb(NO_3)_2$ and vice versa and the conductance measured in reciprocal ohms and plotted against the volume of the titrant added, a distinct break in titration curves is obtained at a point corresponding to the formation of different arsenites depending upon the pH; lead metaarsenite $Pb(AsO_2)_2$ or $PbOAsO_3$ at pH 9·85; white gelatinous precipitate of lead pyroarsenite having the molecular formula $Pb_2As_2O_5$ or $2PbOAs_2O_3$.

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April 1961]

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at pH 11.25 and normal lead orthoarsenite $\text{Pb}_3(\text{AsO}_3)_2$ or $3\text{PbO} \cdot \text{As}_2\text{O}_3$ at pH 12.28.



Figs. 1-2

The conductivity titrations give accurate and dependable results. The addition of alcohol in varying concentrations to the reaction mixture slightly improves the end point, for its presence reduces the adsorption of AsO_4^{3-} and also the solubility of the precipitates and hence a closer approach to the theoretical values is envisaged.

In direct titrations (Fig. 1), on adding alkali arsenite mixture to lead salts, a white precipitate is first formed which settles down quickly. On further addition of the reagent after the end point, the precipitate assumes a colloidal form. In the reverse case (Fig. 2) the precipitate formed remains in colloidal state until the end point is reached, after which it settles down leaving clear supernatant liquid.

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January 19, 1961.

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BEHAVIOUR OF THE CHROMIUM GLYCINE COMPLEX AT THE DROPPING MERCURY ELECTRODE

GLYCINE does not enter into complex ion formation with chromium ions at the ordinary temperature. However, if the mixture is heated for an hour on a water-bath maintained at about 90°, a violet coloured complex is formed. The reduction of this complex at the dropping mercury electrode in different supporting electrolytes, viz., phosphate buffers (pH range 5.20 to 9.7), KCl, and KCl + HCl was investigated.

A mixture of 2.c.c. of glycine (1M) and 1.c.c. of 0.02 chromic chloride was heated on the water-bath until the violet colour was fully developed. 1.5.c.c. of this solution was taken in the polarographic cell and to it 0.5.c.c. gelatine (0.01%) was added and the volume made up to 8.c.c. by the supporting electrolytes. Measurements were made with the help of Fisher Electropode in conjunction with the Multiflex galvanometer type MGF2 in the external circuit. Purified nitrogen was passed in the cell to maintain the inert atmosphere. The temperature was maintained at $35 \pm 0.1^\circ\text{C}$.

The complex was found to be reducible at the dropping mercury electrode but reversible waves were not realised in any of the supporting electrolytes used. The $E_{(1)}$ values and $E_{(2)} - E_{(1)}$ values were as follows :

pH of supporting electrolyte	$E_{(1/2)}$	$E_{(2/4)} - E_{(1/2)}$
Phosphate buffer	5.20	1.10
	6.10	1.24
	6.45	1.26
	6.70	1.26
	6.85	1.30
	7.10	1.32
	8.00	1.32
	8.70	No wave
HCl + KCl (0.1M)	9.70	No wave
KCl (0.1M)	2.30	No well-defined wave
	6.60	0.96
		0.10

From the results it was noticed that only in the case of KCl as supporting electrolyte, a well-defined plateau for the polarographic wave is realised. Even in this case no linear relationship was obtained on plotting $E_{(1)}$ against-

log c of glycine which could help in determining the structure of Cr (iii) glycine complex.

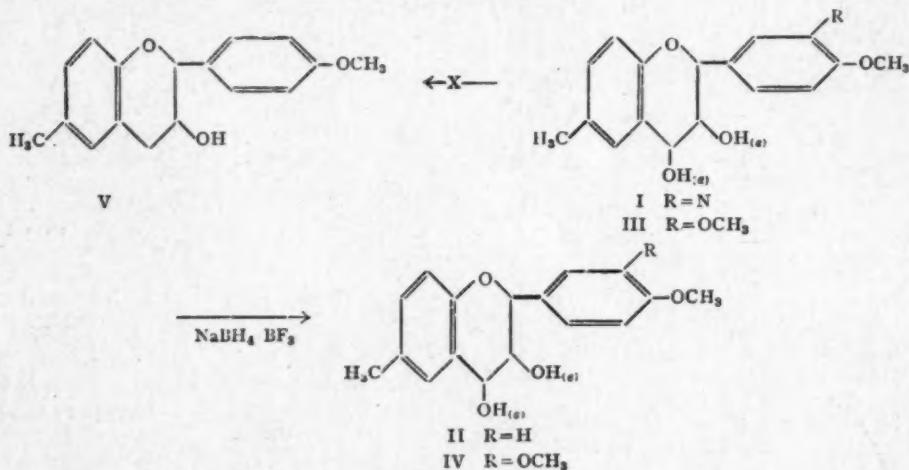
Thanks are due to Prof. M. O. Farooq for his interest in the work.

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December 19, 1960.

EPIMERISATION AT THE C₄-CENTRE OF A FLAVAN-3,4-DIOL

WITH a view to assigning definite stereochemical configurations to the synthetic catechins,¹ the synthesis of the trans-isomer of 6-methyl-4'-

The above method of epimerisation of C₄-OH gives us an elegant method for the synthesis of the trans-diequatorial flavandiol which is hitherto available through the reduction of the dihydroflavonol⁴ in extremely low yields. The general applicability of this epimerisation for the synthesis of a trans diequatorial flavandiol was proved by extending it to the epimerisation of cis-6-methyl-3':4'-dimethoxy flavan-3:4-diol⁶ (III; m.p. 183-84°) to its trans-isomer⁶ (IV; m.p. 203-204°). It is relevant to note that epimerisation of melacacidin [C₄-OH_(s)] to isomelacacidin [C₄-OH_(t)] using hydrochloric acid is very recently reported by Clark-Lewis and Mortimer.⁷



methoxy-3-hydroxyflavan through the hydrogenolysis of the corresponding flavan-3:4-diol, stereochemistry of which is well established,² was attempted. It was recently reported that the reducing action of the metal hydrides is enhanced in presence of certain metal halides such as boron trifluoride and aluminium chloride and that the combined reagent — metal hydride + metal halide is used for hydrogenolysis.³ cis-6-Methyl-4'-methoxy flavan-3:4-diol [I; m.p. 169°; C₃-OH_(s), C₄-OH_(s)] was therefore treated with sodium borohydride boron trifluoride when its trans-isomer [II; m.p. 193°; C₃-OH_(s), C₄-OH_(s)] instead of the expected catechin (V) was isolated in about 40% yield. Sodium borohydride or boron trifluoride alone does not epimerise cis-flavandiol (I). Epimerisation of alcohols with lithium aluminium hydride-aluminium chloride has been reported earlier in the case of 4-t-butylcyclohexanol.⁵

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AN ALL-GLASS SPRAYER FOR PAPER CHROMATOGRAPHY

In recent years, various types of sprayers have been described.¹⁻⁵ Of these Ortegren's apparatus¹ is economical and easy to construct; but in order to get a fine jet of spray, an air-compressor and a finger-controlled port are required during spraying. To reduce the number of accessories, a modification in Ortegren's apparatus was made.

This apparatus (Fig. 1) consists of a reagent reservoir (A) with a quickfit socket (B) of

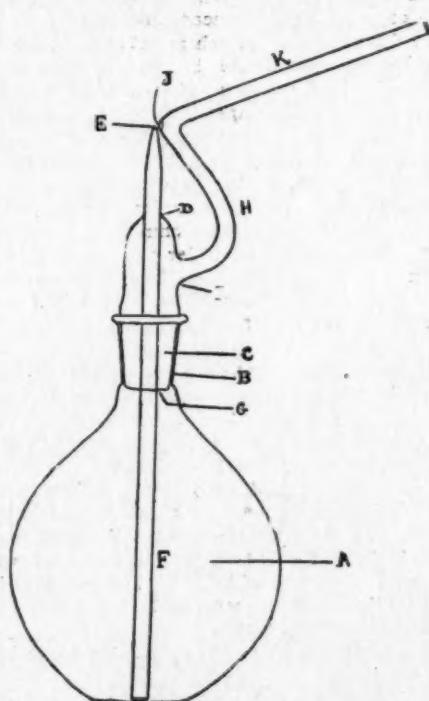


FIG. 1

B₁₉ or any other standard size, and a quickfit cone (C) which exactly fits the socket (B). An uniform pipette nozzle (E) is drawn at D to a distance (DE) of about 3 to 5 cm. The exterior end and interior diameters of the nozzle are 1·0 and 0·5 mm. respectively. A glass tube (F), about 0·5 to 0·8 cm. in diameter and 25 cm. long, is fused to the cone at D. To give greater stability to the pipette in the assembly, the tip of the cone is made to fuse to the pipette column at about three or four places at G. Another glass tube (H), about 20 cm.

long and of the same diameter as the pipette column, is fused at I, about 2·5 cm. from the ground joint. A circular aperture (J), about 2·0 mm. in diameter is blown at the exterior surface, i.e., facing the pipette and about 6 to 8 cm. from the fused end. The curvature of this glass tube is so adjusted that the aperture is situated about 0·5 mm. below the pipette nozzle and 1·0 mm. above it, while its side arm (K) which is about 10 cm. in length lies at approximately $\angle 100^\circ$ to the pipette. The tube F is cut to the size of the reservoir flask. The entire assembly is made of pyrex glass and the construction can be completed within 30 minutes. By using interchangeable joints, the sprayer can be made to fit flasks of any size or even a test-tube.

The sprayer modified in this laboratory has the following advantages:—(i) it is economical, i.e., the entire assembly is of glass and can be easily constructed, while the size of the reservoir flask may be adjusted according to the needs of the operator; (ii) spraying can be done with an air-compressor or by blowing with the mouth as desired; (iii) drops do not form while spraying; (iv) contamination and evaporation of the reagent (when the sprayer is not in use) can be minimized by using a quickfit stopper and (v) it can be dismantled and cleaned easily and, if required, it can be heated.

Institute of Science,
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February 18, 1961.

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HIGH STRETCH PAPER FROM SISAL FIBRE

In an earlier communication¹ results of an investigation on the production of high stretch paper from coconut coir fibre were reported. It was suggested to us by Dr. D. Narayana-murti that sisal fibre should also be capable of high stretch as its spiral angle is large (18–35° according to Heyn; 25–38° according to Sonntag²; and 23° according to Bell³). Therefore, an investigation was undertaken on the strength properties of standard sheets produced from sisal fibre by the sulphate process (NaOH : Na₂S = 3 : 1). The results are recorded in Table I. Comparative figures for

coconut coir taken from the earlier communication¹ are also included in the table.

TABLE I
Sulphate digestions of sisal fibre and strength properties of standard sheets

Serial No.	Digestion conditions and pulp yields			Strength properties of standard sheets made from pulp beaten to 200 ml. freeness				
	Total chemicals*	Digestion temperature	Digestion period	Unbleached pulp yield*	Breaking length	Stretch	Tear factor	Burst factor
%	° C.	Hours	%	Metres	%			
1	14	162	3	66.0	6790	6.2	124	48.4
2	14	162	4	59.4	6900	6.5	133	55.0
3	16	162	3	60.8	8100	8.4	162	59.0
4	20	162	3	57.0	7780	7.7	134	57.4
5†	20	170	4	44.6	4350	9.0	107	56.4

* The % is expressed on the basis of the raw material (oven dry).

† Coconut coir used.

Under the conditions studied, the digestion conditions given in Serial No. 3 give the best results. Although the stretch of paper from sisal is slightly less than that from coir, the yield is much higher and the other strength properties are better. The colour of the paper from sisal is light-brown while that from coir is dark-brown.

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MERCUCROCHROME AS A SPRAY REAGENT FOR AMMONIUM SALTS OF VOLATILE ORGANIC ACIDS

MERCUCROCHROME has been employed as an indicator in acid alkali titration¹ as well as for identification of organic acids on paper chromatograms.^{2,3} This note describes its use as a spray reagent for volatile acids C₁-C₄ in the form of their ammonium salts.

R. L. Reid and M. Lederer⁴ have used bromocresol purple as a spray reagent for ammonium

salts of volatile organic acids, but the spots so obtained fade away rather quickly whereas those obtained with 0.1% mercucrochrome in alcohol stay much longer, over several days. These spots are red in colour whereas those due to organic acids themselves^{2,3} are white. In both the cases the background is pink and spots fluoresce under ultra-violet. It was also found that the ammonium salts of volatile organic acids lent themselves to detection even in as low a concentration as 75 μ gm. when mercucrochrome was used.

In the present investigation where the volatile organic acids produced during the progressive decomposition of fish are studied, mercucrochrome was found to be an effective spray reagent. The presence of organic acids was detected by using paper chromatographic technique. Volatile organic acids were obtained by steam distillation of fish muscle,⁵ and were titrated against sodium hydroxide thus converting them into sodium salts. These sodium salts were converted into ammonium salts and were then applied to a filter-paper disk (Whatman filter-paper No. 1). The chromatogram was developed with n-butanol saturated with an equal volume of 1.5 N aqueous ammonia.⁴ It was sprayed with 0.1% mercucrochrome when red bands due to ammonium salts of volatile organic acids appeared almost immediately against pink background.

The volatile organic acids so identified in the present investigation were formic acid, acetic acid, propionic acid, butyric acid. Acetic acid and butyric acid were found to be present in fresh fish extracts while formic acid, acetic acid, propionic acid and butyric acid appeared after 6 hours of decomposition. Further confirmation and estimation of these acids has been done using silica gel column.

The author thanks Dr. J. W. Airan for help and guidance.

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ENDOTROPHIC SPORULATION AMONG SPECIES OF *STREPTOMYCES*

EARLIER studies in this laboratory on the nature of bacterial sporulation in aerobic sporeforming bacilli had revealed that the ability to sporulate endotrophically is widely distributed among species of the genus *Bacillus*.¹ While sporulation in the branched *Streptomyces* has undoubtedly certain distinctive features, a question raised by the earlier observations was whether the ability to sporulate in an environment that does not support growth is shared by species of *Streptomyces*, a bacterial genus with morphological and reproductive similarities to the typical moulds.

Fourteen authentic strains of *Streptomyces* representative of eleven species were examined. Vegetative mycelia free from spores were obtained as follows: free spores harvested from glucose yeast extract agar² were inoculated into 5.0 ml. of glucose yeast extract broth in 2.0 cm. × 6.0 cm. tubes and incubated in a sloped position which provided a good surface : volume ratio. Almost all spores germinated under these conditions in 36 to 48 hours when the incubation temperature was 27°–29° C. In each case, the absence of observable ungerminated spores was confirmed by careful microscopic examination. The vegetative mycelia thus obtained were washed four times in glass distilled water by centrifugation and suspended in 8.0 ml. of the water. The tubes were incubated at 27°–29° C. and microscopic observations for endotrophic sporulation made at intervals of 5, 7, 15 and 26 days. All microscopic observations were made on crystal-violet stained smears and at a magnification of $\times 1,000$.

No mycelial growth was observed microscopically under these conditions. The results recorded in Table I suggest that the ability to sporulate endotrophically is distributed widely among the *Streptomyces* as was demonstrated earlier in the genus *Bacillus*.¹ Eight of the fourteen strains sporulate appreciably in 5 to 7 days while in the remaining strains the process is extended to 15 or even 26 days. Even within a single species there are notable differences among strains in the facility with which they sporulate. The morphology of mycelia that sporulate was found to be no different from the typical conidiospore-bearing hyphae of *Streptomyces* growing on liquid nutrient media.

This hitherto unreported observation that sporulation in many species of *Streptomyces* is an event which, as in the endospore-forming bacteria, can occur in the absence of growth and multiplication, suggests biochemical ana-

TABLE I

The ability of species and strains of *Streptomyces* to sporulate endotrophically in distilled water

Species and strain	Minimum time (days) required for appreciable* sporulation
<i>S. griseus</i> , MA-13	.. 5
<i>S. griseus</i> , B-110	.. 7
<i>S. violaceoruber</i> , genes, B-1511	.. 5
<i>S. lavendulae</i> , B-1230	.. 7
<i>S. cinnamomeus</i> forma <i>cinnamomeus</i> , H-1285	15
<i>S. nesropis</i> , 2208	.. 5
<i>S. albus</i> , B-1685	.. 26
<i>S. albus</i> , S ₁₂	.. 15
<i>S. ruber</i> , S ₁₃	.. 5
<i>S. annulatus</i> , S ₁₄	.. 26
<i>S. flavus</i> , S ₁₅	.. 7
<i>S. lavendulae</i> , S ₁₇	.. 5
<i>S. antibioticus</i> , S ₁₈	.. 26
<i>S. fradiae</i> , S ₂₀	.. 26

* At least an average of 50 spores observed per field at 1,000 magnification.

The strains used were made available through the courtesy of H. B. Woodruff, T. G. Pridham and Y. M. Freitas, to whom we are grateful.

logies between the sporulation process in bacilli and in *Streptomyces*.

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SCREENING OF RICE VARIETIES FOR RESISTANCE TO FOOT-ROT DISEASE

Gibberella fujikuroi (Saw.) Wr. causes the 'bakanae' disease of rice in Japan, while the imperfect form of this fungus, *Fusarium moniliforme* Sheld., causes the foot-rot disease of rice in India. The disease, though found to occur in many parts of India, has been reported to cause severe damage in Madras and Andhra States.¹ The ideal method of obviating loss due to disease is growing resistant or immune varieties. The present paper reports six new rice varieties resistant to the foot-rot disease (details to be published later), in addition to the few that had already been reported.²⁻⁴

The experiments were conducted in pots containing 250 g. sterilized soil. Twenty new

varieties of rice of Indian, Japanese and Egyptian origin were grown in *F. moniliforme* infested soil along with the controls MTU. 9 (susceptible) and PTB.7 (resistant). Four replicates were maintained for each variety with 15 seedlings per pot. The inoculum for the infested soil was given as follows: The fungus *F. moniliforme* was grown in sterilized soil-oats (9:1) for 21 days, then mixed with sterilized soil at 8% level and incubated for 24 hours. The seeds of the different varieties were surface sterilized with 1 in 1000 mercuric chloride, then sown and irrigated. The seeds sown in uninfested soil formed the controls.

HR. 98. Barring the two varieties PLA. 1 and HR. 35 which have been classified as moderately susceptible, the rest were all highly susceptible. Even the varieties resistant to the disease, however, were not immune; they take infection as seen by the presence of the fungus on plating out.

Of the six varieties now found to be resistant to the disease, HR. 98 (HR. 19 × Norin. 18), HR. 101 (Norin. 20 × HR. 19) and HR. 105 (Norin. 36 × HR. 19) are recently evolved *Indica* × *Japonica* hybrids from Andhra Pradesh. They are white-riced, medium to fine in quality, non-lodging, high yielding and of short dura-

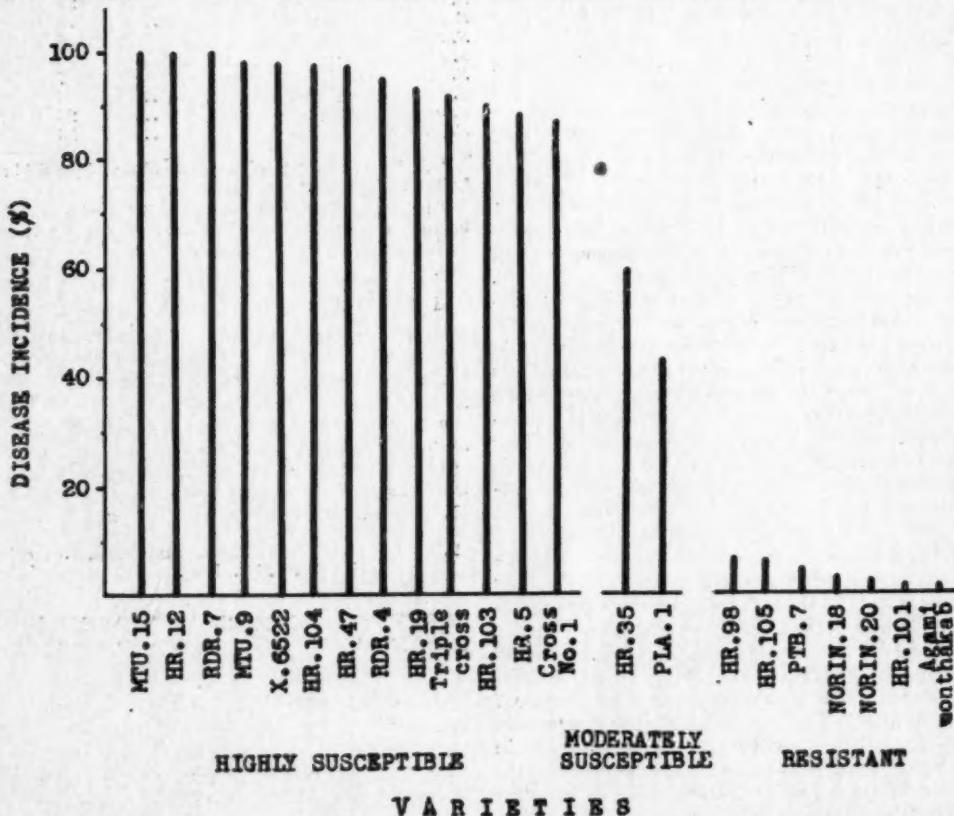


FIG. 1. Shows disease incidence on the 20th day after sowing. (The resistant varieties showed 1.7 to 6.7% disease incidence whereas the susceptible varieties showed a range of 43.3 to 100% incidence.)

The results are presented in Fig. 1 and have been found to be statistically significant at 5% level. The following six varieties are resistant to the disease: Agami monthakab, HR. 101, Norin. 18, Norin. 20, HR. 105 and

PLA. 1. These may be found useful where foot-rot is prevalent. The other three are coarse-grained *Japonica* types which may be useful for hybridization to induce foot-rot disease resistance in susceptible varieties.

I am deeply indebted to Prof. T. S. Sadasivan, Director, University Botany Laboratory, Madras, for encouragement during this investigation.
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THE SANASAR CIRQUE

THAT the Jammu hills in and around Batote and other similarly situated hills in the range were extensively glaciated during the Great or the Pleistocene Ice-age lasting for nearly 50,000 years has been established by unmistakable evidences such as the grooved and polished rock surfaces in these hills¹ and the polished, striated and faceted boulders and pebbles enclosed in the upper Siwalik and Sub-Recent fluvioglacial deposits met with in the neighbourhood of Jammu.^{2,3}

Another evidence equally convincing and dependable of the existence of extensive snow-fields and glaciers in these hills during the Pleistocene times has been recently observed by the author at Sanasar, a picturesque hill-station, about 8,000 feet high above sea-level and some seven miles West of Batote. It consists of a vast spectacular depression called in glacial terminology a *cirque*, about half a mile long and a quarter mile wide, unaffected and unchanged by geological agencies. It has a distinctly amphitheatrical or horse-shoe-shaped outline, with precipitous and cliff-like high headwall, a much lower outer rock-edge on the opposite margin and a typical form of floor that gradually deepens more and more as the headwall is approached. It is this peculiar and reversed slope of the floor, resembling the seat of a gigantic easy-chair that is considered to be "the most dependable criterion for the identification of a cirque".⁴

It is at present occupied by a shallow marshy cirque-lake with a tiny stream issuing out of it through a cut in the outer rock-edge. The high precipitous headwall is evidently the result of quarrying action of ice on the back side of the great crevasse in the cirque-ice called the *bergschrund*. Some smaller cirques have also been observed in the hills, as for example, the Ashapati in Bhadarwah, but the Sanasar cirque is easily the most unique in the Himalayan

ranges South of the Pirpanjal, not only in respect of its extensive dimensions but for its clear-cut topography and outline. The size of the cirque provides an indication of the severity and duration of the glacial cycle in the Jammu hills so close to the plains of the State and the Punjab.

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CEREBROSPINAL LEPTOSPIROSIS IN BUFFALO-CALVES

DUE TO *LEPTOSPIRA HEBDOMADIS*

Losses due to a mysterious disease, characterised by convulsions, prostration and death in 3 to 4 hours in acute cases and by posterior paralysis in sub-acute and chronic forms were encountered among buffalo-calves at the Tarai State Farm dairy, Naini Tal, in India.

Mortality reached a peak in 1958 when as many as 101 out of 149 calves died on the same farm. The affected calves exhibited symptoms like stiffness of gait, inco-ordination of movement, weakness of hind-quarters, paralysis and ultimately recumbency and death. None of the calves showed haemoglobinuria and haematuria. It is interesting to note that the attendant signs of anaemia and haemoglobinuria of *L. hebdomadis* infection in bovines in Japan were not seen in India. Mostly the disease was afebrile and blood smears revealed no protozoa of aetiological significance.

Detailed post-mortem examination was carried out on three sick buffalo-calves that were transhipped to the Institute at Izatnagar, located at a distance of 50 miles from the dairy farm. All the internal organs appeared normal. Histological examination of sections of kidneys showed mild interstitial nephritis, the pattern of which led the senior author to look for leptospire which were demonstrated in Levaditi's stained sections. Consequent on histological evidence of leptospirosis, cultural studies were undertaken on three buffalo-calves showing the typical syndrome. Leptospiræ were isolated from suspensions of kidney, brain and lumbar portion of the spinal cord on inoculation into guinea-pigs and two-day-old baby chicks¹ as well as on direct seeding of Scuffner's modification of Vervoot's medium

and the tryptose-phosphate agar medium developed by Cox and Larson² (1957). Lepto-spiral soluble antigens were demonstrated in gel-diffusion plates when they reacted with rabbit hyperimmune serum to give a double zone. Further haemagglutination, haemolysis and corresponding inhibition⁴ tests confirmed their presence in urine as well. By agglutination and cross-agglutinin absorption tests, the isolate was found to be serologically identical with *Leptospira hebdomadis*. Leptospiræmia occurred on the sixth day in baby chicks and weanling guinea-pigs inoculated intraperitoneally with kidney, brain and spinal-cord emulsions but not with those prepared from liver, spleen and lungs. Viable leptospiræ were recovered in culture from these experimental animals. Experimental induction of the syndrome had since been achieved in healthy buffalo-calves on intra-conjunctival exposure to this serotype.

Serological examination of the blood samples of clinically sick calves showed high titres in the modified Cox's haemolytic test⁵ (1 : 512 to 1 : 1024) and rapid plate agglutination techniques^{6,7} (1 : 50 to 1 : 100). In the microscopic agglutination test, antibodies were found to be specifically directed against *L. hebdomadis* to titres of 1 : 20,000 to 1 : 40,000 and no cross-reaction or heterologous co-reactions were encountered. A random sample survey of the entire herd showed serological evidence of infection in as many as 30 out of 160 buffalocalves. It is interesting to observe that many serologically positive reactors were asymptomatic. Also, a total of 95 adult buffalo-calves were screened when 25 animals reacted positively in the different serological tests.

Leptospira hebdomadis bacterin has since been employed to attempt controlling of losses due to this condition on this farm.

Though, *Leptospira pomona* was found to cause meningitis in cattle^{8,9} the diagnosis, as observed from published reports, had been based on serological or cultural grounds.

This is the first authentic report on cerebro-spinal leptospirosis due to *Leptospira hebdomadis* in cattle in India. To our knowledge, this is the second area of the world where infections of cattle with *L. hebdomadis* have been definitively demonstrated, the other being Japan.

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A HÆMATOXYLIN SQUASH TECHNIQUE FOR A STUDY OF THE NUCLEI OF RAT LIVER CELLS

The hæmatoxylin squash technique devised recently for plant material¹ gave elegant staining of the nuclear organelles. It enabled a determination of the chromosome number of *Dolichos lablab*¹ and a demonstration of chromosomes with tandem satellites in some specimens of *Cicer arietinum*.² Unlike some of the staining procedures^{3,4} hæmatoxylin colours both the chromosomes and nucleoli irrespective of the composition of the fixative. It was thought desirable, therefore, to evaluate the suitability of the above technique for animal tissues.

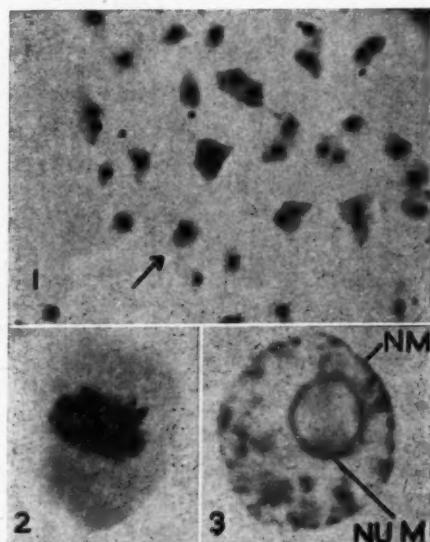
Small bits of the liver of white rat, about 1 mm. in thickness, were fixed in acetic alcohol (1 : 3) for 1 hr. and stored in 70% alcohol. When required, the material was down-graded and kept in water for 30 min. The bits were hydrolysed in N HCl at 60° C. for 5-6 min., washed in distilled water for 10 min., mordanted in 4% ferric ammonium sulphate for 10-20 min., washed well in distilled water for 10 min. and then stained with 0.5% solution of dark hæmatoxylin (Gurr) for 30 min.

A piece of the stained material washed well in water was transferred to a drop of 45% acetic acid on a slide and squashed under a coverslip coated with a thin layer of Mayer's albumen. When occasionally the separation of the cells was found unsatisfactory, the material was softened with 45% acetic acid at 60° C. for 2-6 min. before squashing. The process of softening has to be controlled carefully since acetic acid is also the medium used for destaining.

Temporary mounts sealed with paraffin wax could be kept for a week without loss of clarity. To make them permanent, the coverslips were released in a mixture of 45% acetic acid and tertiary butyl alcohol (3 : 1). The slides and coverslips were upgraded through mixtures of these reagents (1 : 1, 1 : 3) followed by two changes of 30 min. each of pure tertiary butyl alcohol. They were then recombined while mounting in canada balsam dissolved in tertiary butyl alcohol.

Figure 1 is of a field taken under the low power of the microscope to illustrate the separation of the cells. They were generally uni- or bi-nucleate. A rare divisional phase in the above field (indicated by arrow in Fig. 1) is shown in Fig. 2. The most interesting feature was the presence of a distinctly stained and well-defined membrane for the nucleolus (Fig. 3). This was rather surprising since

recent studies with the electron microscope^{5,6} could not substantiate the earlier claims regarding its existence. Confirmatory evidence for the presence of a nucleolar membrane is now being marshalled using a variety of staining techniques.



FIGS. 1-3. Fig. 1. Permanent Mount, $\times 100$. Note the separation of the cells. Fig. 2. The cell indicated by an arrow in Fig. 1 enlarged to show the divisional phase, $\times 1,000$. Fig. 3. Temporary Mount. The nucleus and nucleolus are bounded by membranes, $\times 2,000$.

NM, Nuclear Membrane. NUM, Nucleolar Membrane.

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THE HOST RANGE OF SUGARCANE ROOT-KNOT NEMATODE, *MEOLOIDOGYNE JAVANICA* (TRUEB) CHITWOOD

In an earlier report from this laboratory the occurrence of *Meloidogyne javanica* (Trueb) Chitwood on sugarcane causing root-knot was reported; the same nematode was also found on the weeds *Acalypha indica* L., *Gynandropsis pentaphylla* DC. Prodr. and *Cleome viscosa* L., and on artificial inoculation the nematode was found to infect both sugarcane and *A. indica*.¹ Further studies were made to examine the host range of the nematode and the results are reported here.

The methods of isolating the nematode from sugarcane and inoculating the test plants were the same as were used in the previous studies. Most of the plant species occurring as common weeds in the sugarcane fields in this tract were collected and grown in sterilized soil in pots. The plants were inoculated by drenching the soil with the nematode suspension obtained from the knotted sugarcane roots. Eight plants in each species were inoculated. After an interval of 40 days after inoculation the plants were pulled out and examined. First set of inoculations were made in June 1960 and such of the plant species which failed to take infection were tested again in September, 1960, using a fresh set of plants. The results obtained are summarized in Table I.

In general the infected plants developed chlorotic symptoms and so could be easily differentiated from the uninoculated ones, even without examining the roots. The degrees of severity of infection in the case of *Corchorus acutangulus*, *Eclipta alba* and *Boerhaavia diffusa* were compared by counting the number of galls on the infected and uninoculated check plants and by measuring the gall size. The results indicated that in the case of *Corchorus acutangulus* the average root length was reduced from 35.8 cm. to 22.4 cm. (37.8% reduction); there were on an average 300 galls on each plant and the size of the galls varied from 1 to 7 mm. in diameter. In *Eclipta alba* the average root length was reduced from 37.8 cm. to 20.4 cm. (46.1% reduction); there were an average of 348 galls on each plant and the gall size varied from 0.5 to 2 mm. in diameter. In *Boerhaavia diffusa* the root length was reduced from 39.3 cm. to 27.3 cm. (31.6% reduction); there were on an average of 206 galls per plant and the size varied from 0.5 to 2 mm. in diameter.

The results indicate that this nematode can infect 10 out of 21 plant species tested of which

TABLE I
The host range of *Meloidogyne javanica* from sugarcane

S. No.	Host plant	Intensity of nematode infection	Symptoms produced
1	<i>Amaranthus viridis</i> L.	++	Mild infection, galls on the tap roots only
2	<i>Aristolochia bracteata</i> Retz.	0	..
3	<i>Boerhaavia diffusa</i> L.	+++	Severe infection with mosaic-like symptoms on the leaves; galls mostly on the tap roots
4	<i>Cassia occidentalis</i> L.	0	..
5	<i>Cleome viscosa</i> L.	++++	Severe galling mostly on the tap roots
6	<i>Convolvulus arvensis</i> L.	++++	Severe infection; galls mostly on the secondary and tertiary roots
7	<i>Corchorus acutangulus</i> Lam.	++++	Severe infection and galls found on the tap, secondary and tertiary roots
8	<i>Croton sparsiflorus</i> Morong.	0	..
9	<i>Euphorbia hirta</i> L.	0	..
10	<i>Eclipta alba</i> Hass.	+++	Severe galling, more galls on secondary roots than on the tap root
11	<i>Gomphrena decumbens</i> Jacq.	++++	Severe galling, galls on the tap and secondary roots
12	<i>Gynandropsis pentaphylla</i> DC.	+++	do.
13	<i>Lippia nodiflora</i> Mich.	0	..
14	<i>Malvastrum coronandelianum</i> Garcke.	0	..
15	<i>Ocimum sanctum</i> L.	+	Very mild infection with minute galls on the secondary roots
16	<i>Pavonia zeylanica</i> Cav.	0	..
17	<i>Phyllanthus niruri</i> L.	0	..
18	<i>Sojaum nigrum</i> L.	+	Mild infection on the tap and secondary roots
19	<i>Trianthema portulacastrum</i> L.	0	..
20	<i>Tridax procumbens</i> L.	0	..
21	<i>Vernonia cinerea</i> Less.	0	..

0 = No infection; + to ++++ = increasing intensities of nematode infection.

7 hosts were affected severely. Samad² recently reported *M. javanica* on *Ageratum conyzoides*, *Celosia argentea* and *Cleome viscosa* in Pakistan. According to Edward and Naim³ an unidentified species of *Meloidogyne* occurring in Allahabad could infect many host plants and no host specialisation was evident. In the present studies there were indications of *M. javanica* affecting only some of the plant species tested and not all of them. Also there were variations in the reaction of the different plant species to the nematode infection; in *Corchorus acutangulus* large galls were found while in *Ocimum sanctum* the galls were minute; in *Eclipta alba* galls were more on the secondary roots than on the tap root, whereas in *Corchorus acutangulus* and *Gomphrena decumbens* the galls were equally distributed on the tap root and on the secondary and tertiary roots.

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A NOTE ON THE CHROMOSOME COMPLEMENT OF TRIGONOMORPHA CRENULATA THUMB (ORTHOPTERA: TETTIGONIDAE)

SOME 24 species of the family Tettigonidae belonging to 11 subfamilies have been reported cytologically by Woolsey,¹ King,² Pearson,³ Li,⁴ Winiwarter,⁵ Favrelle⁶ and White.⁷ The present investigation of the species *Trigonomorpha crenulata* belonging to the subfamily Phaneropterinae is an addition to the eight species already noted cytologically.

A few adult male specimens were collected from the suburb of Pondicherry in May 1959. The testes were fixed in Sanfelice's fixative. Sections were cut at 18-22 μ in thickness and stained in iodine-crystal violet and Heidenhain's iron-haematoxylin with satisfactory results.

The X-chromosome is heteropycnotic and eccentrically placed during early prophase (Fig. 1). Spermatogonial metaphase plate consists of $2n = 19$ chromosomes (Fig. 2) unlike other species of Phaneropterinae where $2n = 31$. In the chromosome garniture the X-chromosome without exception lies on the peripheral position of the nucleus where other bigger autosomes

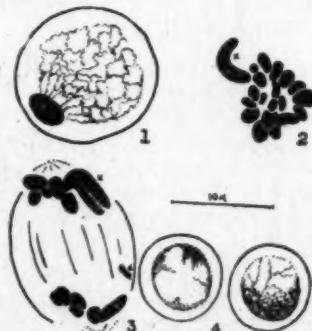
also aggregate. There are 3-4 bent chromosomes including X which seems to be mediocentric. The rest of the autosomes are rod-shaped. Broadly the chromosomes can be classified as 1 long, 9 short and 9 medium-size classes. Sex-determining mechanism seems to be $XX\text{♀}-XO\text{♂}$ type. During first division anaphase disjunction (Fig. 3) X moves to one pole indicating a reductional division for the sex chromosome.

counted; the total value represented the size of that chromosome. The mean value of each chromosome was computed from the data of 10 different nuclei and the relative percentage length of each chromosome was calculated by taking the total of the entire mean results of the chromosome complement as equal to hundred. The following data in Table I indicate the mean number of squares occupied and the percentage

TABLE I

Chromosomes	X	1	2	3	4	5	6	7	8	9
Mean No. of square	..	206.00	97.50	86.50	76.50	68.00	62.25	59.25	54.50	52.50
Percentage length	..	18.45	8.73	7.75	6.84	6.09	5.48	5.31	4.88	4.70
Chromosomes	10	11	12	13	14	15	16	17	18	
Mean No. of square	..	46.25	42.25	39.75	37.00	35.25	33.00	28.75	27.25	24.25
Percentage length	..	4.14	3.8	3.56	3.36	3.14	2.96	2.58	2.44	2.17

At the end of second maturation division each early spermatid (Fig. 4) resulting from two



FIGS. 1-4. Fig. 1. Spermatogonial prophase. Fig. 2. Spermatogonial metaphase. Fig. 3. First division anaphase (other chromosomes could not be traced). Fig. 4. Erythroblast.

daughter cells contains a mass of loosely broken chromatin matter. The quantitative variation of the heteropycnotic element in the two nuclei might be due to the presence or absence of the X chromosome.

A karyotype analysis by means of accurate measurements of the spermatogonial metaphase chromosomes has been made. Drawings of 10 spermatogonial cells selected at random from different slides were projected on a graph-paper with the aid of epidiascope and were traced on it. The total number of full squares ($\frac{1}{2}$ and more than $\frac{1}{2}$ squares were taken as full squares) occupied by each chromosome were

length of the chromosomes: In the graph (Fig. 5) plotted from the above data, abscissa and ordinate represent the number of squares and the percentage length of the chromosomes respectively. It indicates a clear picture of the deviation of X in magnitude with an average value of $X/A = 0.224$. Of the eight species already studied three have mediocentric X

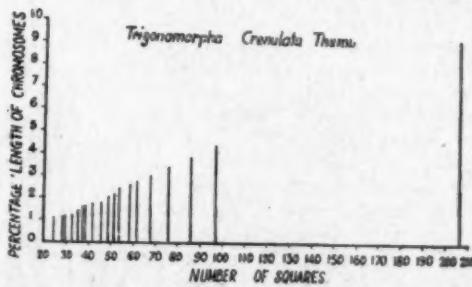


FIG. 5

chromosomes and five have telocentri ones, having the average value of $X/A = 0.157$ and 0.158 respectively. As the differences are not clearly significant, it led White (1941) to presume that the difference between mediocentric and telocentric X's in this subfamily depends solely on structural rearrangements inside the X and not on any transference of autosomal chromosome regions to the X or vice versa. But the value of X/A in the present case is so significantly great that it tends to hint at a contrary view involving an interchange of material from X-chromosome and autosomes.

The author expresses his thanks to Dr. S. G. Vengsarkar, Principal, and Dr. J. C. Saha, Professor of Biology, for the encouragement and laboratory facilities. Sincere gratitude to Dr. A. P. Kapur, Zoological Survey of India, for identification of the specimen. Thanks are also due to Dr. S. K. Lal, Professor-in-charge of Physiology, for helping with some equipment and to Miss C. V. Gracy for technical assistance.

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NOTES ON SOME RECORDED AND UNRECORDED PLANTS WITH KUSMI STRAIN OF THE LAC INSECT

WATT (1901) published first the list of host plants of the common lac insect, *L. lacca* (Kerr); he enumerated 56 species as occurring in India, Burma and Ceylon. Stebbing (1910) increased this number to 88. Lately Roonwal et al. (1958) published a comprehensive list, recording 192 species in all. While these lists contain useful information about the various lac hosts as well as lac cultivation on them, the information as to the strain of the lac insect that thrives on these hosts is mostly lacking presumably because complete information in this regard is yet to be collected. To fill this gap, and specially to discover alternative hosts for the Kusmi strain a survey was carried out in December 1959 of the Taimara area in Ranchi Forest Division, Chotanagpur (18 miles away from Ranchi), when 12 species of plants showing lac encrustation of the Kusmi strain could be recorded. Of these, 4 species are hitherto unrecorded lac hosts, while in the case of 5 others, Kusmi strain of the lac insect has been recorded for the first time.

The species found with Kusmi lac encrustation are listed below :

- (1) *Semecarpus anacardium* Linn. (*Bhelwa*)
- (2) *Buchanania lanza* Spreng. (*Piyar*)
- (3) *Milletia auriculata* Baker (*Gaj*)
- (4) *Dillenia pentagyna* Roxb. (*Rai*)

New lac host species

- (5) *Mangifera indica* L. (*Am*)
- (6) *Shore robusta* Gaertn. (*Sal*)
- (7) *Butia superba* Roxb. (*Palas lata*)
- (8) *Croton oblongifolius* Roxb. (*Putri*)
- (9) *Ficus tomentosa* (Roxb.)
- (10) *Protium serratum* Engl. (*Kandior*)
- (11) *Dalbergia latifolia* Roxb. (*Sitcal*)
- (12) *Acacia canescens* R. Grah. (*Arar*)

Species on which Kusmi strain is recorded for the first time

Species already known as alternative hosts for Kusmi strain

The area surveyed is a mixed forest having naturally occurring Kusum trees associated with different deciduous species. The Kusum trees are being already exploited by the Bihar Forest Department for lac cultivation. The above 12 species which were observed to be carrying the Kusmi lac encrustation appear to have got accidentally infected from the Kusum brood lac used for the inoculation of Kusum trees in the Aghani 1959-60 season.

Observations made in regard to the lac encrustations on these hosts are given below :—

NEW LAC HOSTS

- (1) *Semecarpus anacardium* Linn. (*Bhelwa*)
(Family—Anacardiaceæ)

Lac infection was observed on only one tree. Most of the twigs carrying lac had patchy and sparse encrustation; the lac cells, however, were well developed. Fairly heavy mortality was observed to have occurred in the early stages of the crop.

- (2) *Buchanania lanza* Spreng. (Syn. *B. latifolia* Roxb.) (*Piyar*)

(Family—Anacardiaceæ)

Only one tree of this species was found to be carrying lac. The settlement of larvae was good and fairly uniform, and larval mortality only slight. Continuous encrustation with well-developed lac cells was found on a large number of twigs. Comparatively thick shoots did not carry any lac.

- (3) *Dillenia pentagyna* Roxb. (*Rai*)

(Family—Dilleniaceæ)

Lac encrustation was found on the midrib and petiole of the leaf but not on the shoots. The accidental infection was partial and occurred only on one half of the tree. The encrustation was continuous with fairly well-developed lac cells. There were about 30 encrusted leaves, the length of encrustation varying from 2" to 6".

(4) *Milletia auriculata* Baker. (Gaj)(Family—Leguminosæ : Subfamily—
Papilionaceæ)

Lac encrustation was found only on leaf stalks and not on shoots. The development of lac cells was quite good. Encrustations were mostly thick and continuous and 6" to 9" long. A good number of plants were found accidentally infected, of which 10 showed fairly well covered lac encrustation all over.

HOSTS ON WHICH *Kusmi* STRAIN WAS RECORDED
FOR THE FIRST TIME(5) *Mangifera indica* Linn. (Am)

(Family—Anacardiaceæ)

Lac was found on two big branches of a tree having been accidentally infected from brood-lac bundles kept under the tree at the time of inoculation. The encrustation was mostly patchy except that a few twigs carried thick and continuous encrustations, 4" to 6" in length.

(6) *Shorea robusta* Gaertn. (Sal)

(Family—Dipterocarpaceæ)

Mostly sparse and patchy lac encrustation with good development of cells was observed on 4 trees. Nearly 30% of the shoots were covered with lac.

(7) *Butea superba* Roxb. (Palas lata)(Family—Leguminosæ : Subfamily—
Papilionaceæ)

Lac was observed on three plants where approximately 25% of the shoots were covered. In some cases thick encrustation of 6" to 8" length was noted. Even the leaf stalks were seen covered with lac encrustation.

(8) *Croton oblongifolius* Roxb. (Putri)

(Family—Euphorbiaceæ)

Sparse as well as continuous lac encrustations were found on a good number of trees. There was lac encrustation practically on every shoot. The development of lac cells, however, was rather poor. Fairly heavy mortality at the larval stage was also observed.

(9) *Ficus tomentosa* Roxb.

(Family—Urticaceæ)

Only one tree of this species was found to be carrying lac. Encrustations were mostly patchy with scattered but well-developed healthy lac cells. Over 50% of the shoots were covered with lac.

SPECIES ALREADY KNOWN AS ALTERNATIVE HOSTS
FOR *Kusmi* STRAIN(10) *Protium serratum* Engl. (Syn. *Bursera serrata* Wall. ex Colebr.)

(Family—Burseraceæ)

While a few trees had been accidentally infected, a few had been deliberately inoculated by the villagers. This species is known to be a fairly satisfactory alternative lac host for the *Kusmi* strain of the lac insect, particularly for growing the *Aghani* crop. Both the artificially inoculated and the naturally infected trees carried thick continuous encrustations.

(11) *Dalbergia latifolia* Roxb. (Sitsal)(Family—Leguminosæ : Subfamily—
Papilionaceæ)

This species is also a known alternative host for the *Kusmi* strain. Lac encrustations were observed on a number of branches of only one tree in the area. Mostly thin shoots at the apical portion were covered with thick and continuous encrustations, 3" to 6" in length.

(12) *Acacia canescens* R. Grah. (Arar)(Family—Leguminosæ : Subfamily—
Mimosaceæ)

Only 2 trees had a few lac-encrusted twigs. The encrustation varying in length from 4" to 6" was thick and continuous and occurred towards the apical portion of the shoots. The cells were well developed.

In the case of all the above 12 species, the lac encrustations retained their characteristic *Kusmi* features, namely, pale colour, typical shape of the lac cells and of the encrustation. They may, therefore, be regarded as good alternative *Kusmi* lac hosts.

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**NOTE ON ABNORMAL CONJUGATION
IN *SPIROGYRA BRAZILIENSIS*
(NORD.) TRANS.**

DURING the normal conjugation in Conjugales, fusion between one male and one female gamete is the general rule. However, cases of abnormal conjugation have been reported in many species of *Spirogyra*,^{1,2,4} *Zygema*,² *Mougeotia*,² and *Desmids*.³ Several types of abnormal conjugations have been described in *Spirogyra* by West and West,⁴ viz., (a) by means of four tubes connecting three cells belonging to two different filaments (Fig. 1 a); (b) by means of four tubes connecting three cells belonging to as many different filaments (Fig. 1 b); (c) by means of three tubes forming a triple connection (Fig. 1 c) and (d) by means of four tubes connecting one cell of one filament and three of another filament² (Fig. 1 d). In all such

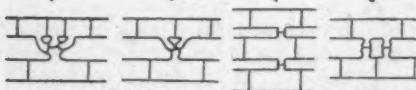


FIG. 1. Diagrammatic sketches of different types of abnormal conjugation in *Spirogyra* spp.

cases, the resulting zygospores are either triploids or tetraploids. Here the terms triploid and tetraploid refer to the fact that more than two protoplasts amalgamate and not to their chromosome numbers, since these observations have been made on preserved materials. Czurda² reported that when the triploid zygospores of *Spirogyra varians* and *S. lacustris* were isolated and germinated the resulting filaments did not show any morphological difference from the normal filaments.

The object of the present communication is to describe two types of abnormal conjugation in *Spirogyra brasiliensis* (Nord.) Trans. collected from Moti Kund near Jodhpur in December 1952 and from Najafgarh Jhil near Delhi in December 1959.

Vegetative cells 38-45.6 μ broad and 60.2-195.8 μ long with plane walls; chloroplasts 3, making 1-3 turns; conjugation scalariform and conjugation tubes formed by both gametangia; fertile cells cylindric; zygospores ellipsoid 53.2-57 μ broad and 76-98.8 (-106.4) μ long; median spore wall minutely verrucose; spores yellowish-brown in colour.

In the normal scalariform conjugation, conjugation tubes are formed by a male and a female gametangium, resulting in the fusion of one male gamete with one female gamete. But in

some abnormal cases, two male gametangia were found to conjugate with a single female gametangium, as a result of which three protoplasts fuse, resulting in the formation of a triploid zygospore (Fig. 4). In such cases, one cell was monopolising the energies of two cells in the opposite filament.



FIGS. 2-4. Abnormal conjugation in *Spirogyra brasiliensis*. Figs. 2-3. Amalgamation of the two fused protoplasts through the dissolved cross septum. Fig. 4. Conjugation between one female and two male gametangia.

In other cases, two male gametangia conjugate with two female gametangia as in normal scalariform conjugation, but the cross septum of the female gametangium dissolves and the two fused protoplasts again fuse with each other (Figs. 2-3). Such zygospores are evidently tetraploids, because of the fusion of four protoplasts.

We are grateful to Dr. B. D. Tiagi, Shri R. M. Bhandari, Dr. M. S. Randhawa, Dr. B. P. Pal and Dr. A. B. Joshi for their interest and

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Letters to the Editor

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encouragement and to Mr. G. S. Venkataraman for his suggestions and help.

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VIABILITY AND FERTILITY OF MONOSOMICS IN *GOSSYPIUM HIRSUTUM*

AMONG plants of *Gossypium hirsutum* L. var. 320-F ($2n = 52$) grown from seeds treated with 60,000 r of X-rays, a plant with $2n = 51$ occurred. During meiosis in the microsporocytes of this monosomic plant, 25 bivalents and 1 large univalent were invariably found at diakinesis and metaphase I (Fig. 1). The mean



FIG. 1. Metaphase I of meiosis in *G. hirsutum* showing $25_{II} + 1_I$.

numbers of chiasmata per bivalent in the monosomic and normal disomic plants were 1.50 and 2.26 respectively. The univalent usually lagged and underwent division during anaphase I. The monosomic plant had smaller leaves and flowers in comparison with the control but it was more densely hairy. Though vigorous in growth, the plant was completely pollen and ovule sterile. Pollination with normal pollen and smearing the pedicels with different concentrations of auxins did not help to induce seed setting.

Stebbins¹ has pointed out that considerable differences exist among allopolyploids with regard to their ability to tolerate chromosome deficiencies. Thus, while both nullisomics and genomic substitution are tolerated by bread wheat (*Triticum aestivum*; $2n = 42$), only monosomics are viable in tobacco (*Nicotiana tabacum*; $2n = 48$). The tetraploid cotton species, *G. hirsutum* and *G. barbadense*, were until recently believed to be capable of tolerating only small segmental deficiencies but the

findings of Kammacher et al.² and the present report clearly indicate that in *G. hirsutum* also monosomics are viable. Unlike their counterparts in bread wheat and tobacco, monosomics of tetraploid cotton are completely sterile. The isolation of viable monosomics hence does not affect the view of Stebbins¹ that *G. hirsutum* is a more strict genomic allotetraploid than *N. tabacum* or *T. aestivum*.

The quadruple monosomic isolated by Kammacher et al.² in *G. hirsutum* was of spontaneous origin, while the monosomic studied by us probably arose as a result of radiation induced disjunctional abnormalities during somatic cell division. It is, however, of interest that in both instances the size of the univalents indicated that the chromosomes lost belong to the "A" genome contributed by Asiatic diploid species. No monosomics involving the loss of the New World diploid "D" genome have been found so far. A study of many more monosomics will, however, be necessary to assess the relative importance of different chromosomes in conditioning viability and fertility.

We are indebted to Dr. B. P. Pal and Dr. A. B. Joshi for their interest in this study. Indian Agri. Res. Inst., D. JAGATHESAN. New-Delhi-12, M. S. SWAMINATHAN. December 14, 1960.

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POWDERY MILDEW ON *GMELINA ARBOREA*

A POWDERY mildew on the leaves of *Gmelina arborea* Roxb. (Verbenaceae), a timber tree of some importance was collected near Achalpur, Maharashtra. The fungus was a species of *Phylactinia*. Butler and Bisby (1931) have recorded *Phylactinia suffulta* (Rebent.) Sacc. [Syn. *P. corylea* (Pers.) Karst.] on *Indigofera gerardiana* Grah., *Juglans regia* L., *Morus alba* L., *Pyrus communis* L., *P. pashia* Hom. and *Phylactinia subspiralis* (Sal) Blum. On *Dalbergia sissoo* Roxb. Recently Ramakrishnan (1957) has described *P. heterophragmatis* from *Heterophragma roxburghii* DC. and *P. terminaliae* on *Terminalia chebula* Retz.

The powdery mildew on *Gmelina arborea* produces conspicuously larger cleistothecia than *P. suffulta*. A comparative account of various species described from India is given in Table I.

It is seen from Table I that cleistothecia on *Gmelina arborea* are conspicuously larger than

TABLE I

Species	Cleistothecia		Asci		Ascospores	
	No. of appendages	Diameter μ	Number	Size μ	Size μ	Size μ
<i>P. suffulta</i>	..	6-12	160-230	10-30	70-100 \times 25-40	25-40 \times 15-25
<i>P. heterophragmatis</i>	..	14-18	185-200
<i>P. terminaliae</i>	..	14-18	170-200	..	50-60 \times 24-28	..
<i>P. from Gmelina arborea</i>	5-10	248-322	16-25	80-97 \times 24-34	28-38 \times 17-24 (35) \times (20)	

P. suffulta and also differ in size of ascospores.

In *Index of Fungi* 1922-28, Petrak mentioned only one species of *Phyllactinia* and the rest being put as varieties of *P. suffulta* (Rebent.) Sacc. [*P. corylea* (Pers) Karst.] occurring on numerous hosts, distributed in different parts of the world. In his treatment of *Phyllactinia*, mostly he follows Salmon (1910) who recognized only a single species of *Phyllactinia*. Later, many workers, notably Blumer (1933), Homma (1937), Sawada (1930), Dodge (1948) have raised some of the varieties of Salmon to specific ranks. *P. erythrinae* Dodge, *P. elegni* Lin., *P. actinidiae-formosonae* Saw., *P. moricola* Saw., *P. subspirialis* Blum. are examples of such transfers. Blumer has shown by biometric studies which have been supported by the inoculation experiments of Hommarlund (1925) that there is a greater degree of specificity among the Erysiphaceæ than have been previously acknowledged.

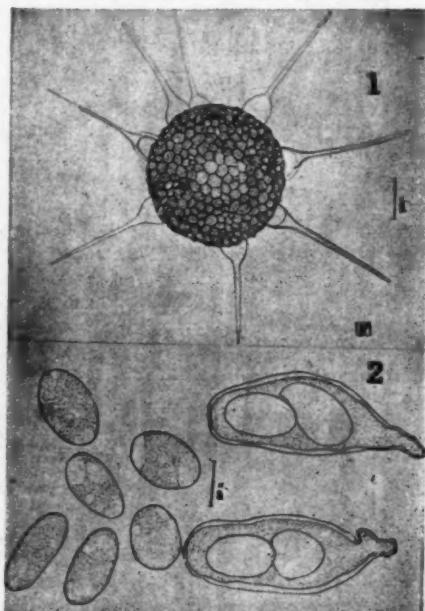
In view of the differences in morphological characters mentioned, it seems desirable to recognize the powdery mildew on *Gmelina arborea* as a new variety of *P. suffulta* with the following description.

Phyllactinia suffulta (Rebent.) Sacc. var. *gmelinæ* var. nov.

Infection spots chiefly hypophyllous, often coalescent and covering the whole leaf, upper surface showing pale-yellow colour. Cleistothecia, abundantly produced, golden-yellow to dark-brown in colour, globose to spherical, 248-322 μ in diameter; appendages in a whorl of 5-10, hyaline with a bulbous base; Ascii 16-25 in number, 80-97 \times 24-34 μ ; 2-spored with golden-yellow contents; ascospores ovate or ellipsoid, 28-38 \times 17-24 μ , with orange-yellow contents.

On *Gmelina arborea* Roxb. (Verbenaceæ) Chikhaldha, Maharashtra State, 20th December 1959, Leg. B. V. Patil.

Sincere thanks are due to Dr. M. J. Thirumalachar, Superintendent, Research, Hindustan



FIGS. 1-2. Fig. 1. Cleistothecium with bulbous appendages. Fig. 2. Ascospores.

Antibiotics Ltd., Pimpri, for his keen interest, helpful criticism and encouragement. I am also indebted to Chairman, M. S. G. College, for facilities at the college laboratory and Forest Department, Maharashtra State, for assistance in the field-work.

M. S. G. College,
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REVIEWS

Proceedings of the International Congress of Mathematicians, 1958. Edited by J. A. Todd, F.R.S. (Cambridge University Press.) Pp. lxiv + 573. Price 65 sh. net.

This volume contains the official record of the International Congress of Mathematicians held in Edinburgh in August 1958.

The introductory lists of officers, committee members and donors are followed by a record of the scientific programme, the Secretary's report, the reports of the inaugural and closing sessions, and an appreciation of the Congress's Fields Medallists. The main body of the work comprises the complete texts of seventeen one-hour and thirty-three half-hour addresses given in Edinburgh at the invitation of the Programme Committee. The one-hour addresses are designed to give broad surveys of all the major developments between 1954 and 1958. From India there is one paper on Hilbert Algebras by S. Minakshisundaram. The half-hour addresses are arranged systematically under the following headings : Logic and Foundations ; Algebra and Theory of Numbers ; Classical Analysis and Functional Analysis ; Topology ; Algebraic Geometry and Differential Geometry ; Probability and Statistics ; Applied Mathematics, Mathematical Physics and Numerical Analysis ; History and Education.

The work as a whole, containing papers in English, French, German and Russian by mathematicians from all parts of the world, presents a comprehensive, international and up-to-date record of mathematical knowledge. The volume will stimulate further research and it can be hoped that it will serve as a focal point from which many of the results of the next few years will be derived.

V.

Some Mathematical Methods of Physics. By G. Goertzel and N. Tralli. (McGraw-Hill Book Co., Inc., 330, West 42nd Street, New York-36, N.Y.), 1960. Pp. xii + 300. Price \$ 8.50.

This book which will be welcomed by advanced students of Physics presents in a clear and consistent manner the common mathematical techniques that are used in different fields of theoretical and applied physics, such as quantum mechanics, acoustics, electromagnetic theory, and reactor physics. The book is divided into three parts. In Part I systems with a finite

number of degrees of freedom (described by matrices) are considered. In Part II these considerations are extended to systems with an infinite number of degrees of freedom, and it includes chapters on the Laplacian in one, two and three dimensions, Green's Functions, and radiation and scattering problems. Part III deals with Approximation Methods and includes Perturbation of Eigenvalues, Variational Methods and Numerical Methods. There is a useful Appendix containing the proofs of many fundamental theorems applied in the text material. At the end of each chapter are given a number of interesting problems.

The authors being teachers of experience in the subject, have developed the material in a way to suit the students' needs. A. S. G.

Analytical Elements of Mechanics, Vol. I. By Thomas R. Kane. (Academic Press, New York and London), 1959. Pp. xv + 250. Price \$ 4.75.

This is a text-book on statics and has been written for students of the degree classes. Vector methods have been employed throughout the book and Chapter I provides an exposition of vector algebra. Each section is supplemented by a number of worked examples, and besides each chapter contains a number of problems. The book will be found to be useful to students and teachers of the degree classes. V.

Advances in Chemical Physics, Vol. II. Edited by I. Prigogine. (Interscience Pub., New York-1, N.Y.), 1959. Pp. ix + 412. Price \$ 11.50.

Chemical physics now includes a much larger variety of topics than what was originally thought of when the term itself came into vogue nearly three decades ago. One consequence of this expansion in the scope of the subject has been that the relevant papers on the topics concerned not only are scattered among a great number of journals but are becoming increasingly terse that anyone who is not an expert in the specific field finds it difficult to follow. Hence this Interscience publication series, "Advances in Chemical Physics" edited by Prof. I. Prigogine, and containing articles of a comprehensive nature, written by experts on the subjects concerned is sure to find popular reception among teachers, students and research

workers. The first volume in this series was published in 1958. The second volume under review contains eight articles.

The first article is on Clathrate solutions by J. H. Van der Waals and J. C. Platteuw. Since the study by Palin and Powell nearly ten years ago of the "peculiar compounds" formed by hydroquinone with a large number of gases and volatile liquids, the chemistry and structure of these molecular complexes known as 'clathrate compounds' have been the subject of study by many workers. These are now known to be formed not only by hydroquinone, but also phenol and a number of related substances. In all clathrates we have a host lattice, by itself thermodynamically unstable, but which is stabilized by inclusion of a second component. Thus clathrate may be considered as a solid solution of the second component in the metastable host lattice. The article is in three parts, the first part deals with the crystal structure of the hydroquinone clathrates and of gas hydrates. The second part is devoted to a rigorous analysis of the thermodynamic behaviour of clathrates, and in the third part heterogeneous equilibria involving clathrates are discussed.

In the second article on inter- and intramolecular forces K. S. Pitzer gives a review of the theoretical methods of calculating the polarizability of molecules and the experimental data concerning the strength of the London forces in molecules. In Chapter 7, Per-Olov Lowden who himself has made significant contributions to the problem of many electron quantum mechanics gives a review of the different approaches made to obtain correlation energy in problems of molecular chemistry and discusses some of the current ideas in this field. The motions of the electrons in atoms, molecules and solids are all correlated with each other and this correlation is of two types, the first arising from the limitation imposed on the motion by the Pauli exclusion principle, and the second owing its origin to the Coulomb repulsion between the electrons. The standard method of solving the many-electron problem in quantum mechanics is by an appeal to the Hartree-Fock equations which take properly into account the exclusion principle, but owing to the use of one-electron wave functions, these equations do not adequately bring into the theoretical formalism the Coulomb repulsion between the electrons. Defining the correlation energy for a certain state as the difference between the exact eigen-value of the Hamiltonian and its expectation value in the Hartree-Fock approximation for that state, the author surveys in

this article the various methods of obtaining a measure of the correlation energy for molecules. This chapter is supplemented by an extensive bibliography.

The study of internal rotations in molecules and the forces interfering with free rotations has interested physical chemists for a long time. The potential energy barriers which come into play, although only of the order of a few thousand calories, are known to markedly influence the properties of isomers. Bright Wilson gives a review of the various methods of measuring potential barriers in the last chapter on "The problem of barriers to internal rotation in molecules". These methods include the thermodynamic method, dipole moment method, electron diffraction, infra-red and Raman spectroscopy, and micro-wave method. He also outlines the various theories of the origin of the barriers.

The other articles in this volume are: Solubility of solids in compressed gases by J. S. Rowlinson and M. J. Richardson; Thermodynamics of metallic solutions by R. A. Oriani; Recent advances in polymer chemistry by M. Szwarc and Nuclear quadrupole resonance in irradiated crystals by Jules Duchesne.

K. S. V.

Lehrbuchen der theoretischen Physik. By George Joos, 10th Edition. (Akademische Verlagsgesellschaft. M. B. H. Frankfurt am Main), 1959. Pp. xxiii + 842, with 212 figures in text.

The Tenth German Edition of the famous text by George Joos—perhaps the best classical book of its type—includes several additions in modern fields. The author did not survive to witness its actual publication and this edition is itself in a sense a fitting commemoration to him. As examples of the additional material, we may mention the sections of Ferro- and Antiferromagnetism, Ferro and Antiferro-electricity, and the wave-mechanical theory of the normal Zeeman effect.

S. P.

Crystal Structures, Supplement V. By R. W. G. Wyckoff. (Interscience Publishers, Inc., New York), 1960. Price \$ 26.50.

This Fifth and Final supplement recently published, completes the successful accomplishment of a monumental work undertaken by one of the world's foremost authorities on crystallography. The author has taken immense pains to make each supplement, as and when published, as up-to-date as possible. He has now, in his latest supplement, revised, expanded by addi-

tions to all the chapters, and given the final touch of fullness to his work by furnishing the Inorganic Formula Index, Mineralogical Name Index and also Index to Organic Compounds (1960). He has thus laid all crystallographers under a deep debt of gratitude.

All these five supplements and sections of the above work should find a place in the library of every Research Institute concerned with crystallography in one or other of the many aspects of the subject.

Fortschritte Der Hochfrequenztechnik, Vol. 4. Edited by J. Zenneck M. Strutt and F. Vilbig. (Akademische Verlagsgesellschaft, M. B. H., Frankfurt am Main), 1959. Pp. 321. Price DM 42.

This book is a collection of progress reports on some of the more important problems of high frequency technique which have engaged the attention of research workers since World War II. Each report is complete in itself and has, at its end, a well selected bibliography. The reports are written in a very lucid style and give a balanced account of the present position of the topic dealt with. The contributors are all persons of real standing in the fields for which they have prepared the reports. Of the eight articles, three are in German.

The topics reviewed, the authors and the language in which it is written are as follows :—
(1) "Scatter propagation" by J. B. Weisner in English ; (2) "LF and VLF propagation" by H. Poeverlein in German ; (3) "Modern HF transistors" by R. H. Pritchard in English ; (4) "Fabrication techniques for HF transistors" by R. N. Hall in English ; (5) "Noise in semiconductors" by A. van der Zeel in English ; (6) "Fluctuation phenomena in electron beams" by H. W. Konig and H. Potzl in German ; (7) "Wave guide mode in a periodic delay line—a mathematical analysis with application to travelling wave tubes" by H. Poschl in German ; and (8) "Getters in electron tubes" by J. S. Wagener in English.

The printing and get-up of the book are excellent. The diagrams are all neatly drawn and well reproduced. All the articles are of real value to students, teachers and research workers in physics and electrical engineering. The book should find a place not only in college and research institution libraries but also on the shelves of students and research workers.

S. V. C.

Heavenly Clockwork. By J. Needham, W. Ling and D. J. Price. (Cambridge University Press, London N.W. 1), 1960. Pp. xv + 253. Price 65 sh.

This great work is the outcome of deep researches by Dr. Needham and his collaborators into the history of science and technology in China. It was generally believed that the mechanical clock with the escapement principle was a European invention of the late 13th century A.D., and that before that time there had been only sundials, water-clocks and sand-glasses. Dr. Needham's researches have brought to light the remarkable fact that there existed a long tradition of astronomical clock-making in China between 725 A.D. and 1370 A.D. (when the art seems to have been lost) when the Chinese constructed and operated elaborate astronomical clocks powered by water and regulated by an effective form of escapement.

The key text for this discovery was the book written by Su Sung in 1090 A.D. entitled *Hsin I Hsiang Fa Yao* [New Design for a (mechanized) Armillary (Sphere) and (Celestial) Globe]. This monograph has preserved for us in unexpected detail the construction of a mechanical clock more than three centuries before the first appearance of such clocks in Europe. The following description of the 'clock' gives the ingenious technique employed in devising the escapement mechanism.

"Su Sung's 'clock' was, in fact, a great astronomical clock-tower more than 30 ft. high, surmounted by a huge bronze power-driven armillary sphere for observation, and containing, in a chamber within, an automatically rotated celestial globe with which the observed places of the heavenly bodies could be compared. Inside the tower was the motive source, a great scoop-wheel using water and turning all the shafts working the various devices. The wheel was checked by an escapement consisting of a sort of weigh-bridge which prevented the fall of a scoop until full, and a trip-lever and parallel linkage system which arrested the forward motion of the wheel at a further point and allowed it to settle back and bring the next scoop into position on the weigh-bridge.... One must imagine this giant structure going off at full-cock every quarter of an hour with a great sound of creaking and splashing, changing and ringing; it must have been impressive, and we know that it was actually built and made to work for many years before being carried away into exile".

The book opens with a biography of that remarkable Chinese scientist-statesman Su Sung

1020-1101 A.D. but for whose monograph this outstanding research into ancient horology would have been impossible. This is followed by an interesting account of the resuscitation of Su Sung's book and its transmission to later times. A translation of the original chapter of the Chinese book on "The water-driven armillary and celestial tower" with 19 illustrations forms the fourth chapter, and the fifth chapter gives in detail the explanation of Su Sung's clock, illustrated with corresponding modern drawings.

In his book Su Sung gave not only a minute account of the stages in the construction of the clock itself but also "a historical disquisition on the instruments of similar kind which had existed in previous centuries". This had enabled Dr. Needham and his collaborators to trace the history of Chinese clock-making to the earlier centuries not only up to the seventh century A.D. but to the time of the great mathematician and astronomer Chang Heng (78-142 A.D.). These researches as well as the history of Chinese clockwork in the centuries following Su Sung's clock form the subject-matter of the sixth and seventh chapters which cover nearly half the book.

There is an interesting chapter where Dr. Needham examines the context of these inventions against the social environments of the Chinese people in the medieval ages, their customs and their superstitions. One fact that stands out foremost is that the Chinese masterpieces of medieval engineering were always connected with the Chinese imperial palace.

In assessing the imperial interest in clock-making research has thrown light on two factors. One is the practice of the issuance of Imperial calendars. The promulgation of an official calendar was one of the most important acts of the Chinese emperor. The clockwork with the powered celestial globe helped to check calendrical computation. The second, and perhaps the more interesting factor, is the one which concerned the succession to the imperial throne. It should be remembered that the Chinese emperor was a cosmic figure, and the private life of the emperor and his hierarchy of queens and consorts was regulated according to the principles of 'numinous cosmism' that pervaded Court life. Primogeniture gave no right to succession. Among the eligible heirs-apparent only he was considered as divinely ordained for the throne at whose conception the stars were in favourable positions. Hence the value of an instrument which not only told the time, but from which one could read off the star positions at any desired moment.

The book is scholarly. It keeps the interest of the reader to the end by the comments and stories concerning conditions, customs and politics in medieval China—all told in an inimitable and sympathetic style.

A. S. G.

The History of Science and Engineering in the Lands of the Orient. (United Soviet National Bureau for the History of Natural Science and Engineering, Moscow, USSR), 1960. (In Russian.) Pp. 474.

No history of science would be complete if it did not include an analysis of the contribution made by the eastern peoples. The editors of the volume under review have set upon themselves the task of tracing the history of the development and progress through ages in the fields of science and engineering in the countries of the East. The reader is impressed with the thoroughness and painstaking devotion that have gone into the preparation of the collection of articles embodied in this volume.

Of particular interest to us in India is the second part which, running to over 200 pages, gives an extensive survey of science in India and includes a bibliography of over 500 references. The chapter entitled "Water Resources and their Utilization in India" runs the whole gamut of the indigenous methods of irrigation, dams, and waterways, to the great hydroelectric projects which have come up during the Five-Year Plans of the Republic of India, as for example, the Damodar Valley Scheme, Bhakra-Nangal, Machkund, etc. There are accounts of the exchange of scientific delegations between Russia and India over the years, and sections devoted to research in the field of physics, medical conditions in India, the establishment of Indological and Sanskritic studies in the Russian Universities.

Perfumes, Cosmetics and Soaps. By W. A. Poucher, Vol. 3. A Treatise on Modern Cosmetics. VII Edition Revised. (Chapman and Hall, London), 1959. Pp. xi + 260. Price 45 sh.

The appearance of this the seventh edition of the third volume of Poucher's well-known treatise is by itself eloquent testimony to the worth and esteem in which the entire series is held by the profession. The third volume is devoted to modern cosmetics.

As usual with the Poucher volumes, this book covers a wide range of cosmetics and contains an impressive range of formulæ. These, together with the explanatory information, have

the merit of being basically sound but do not always do justice to the newer and very versatile cosmetic chemicals which are finding increasing application in the industry today. In Poucher's treatment, the emphasis is on simplicity of formulation and processing rather than on modernity. Only occasional glimpses of these new trends are revealed as, for example, a new formula for an indelible lipstick with tetrahydro furfuryl alcohol, and formulations for a pre-electric shave lotion, deodorants and deodorant sticks using hexachlorophene (G. 11). There is also mention of new formulæ for talcum powders with G. 11. It is therefore all the more surprising that there is not even a passing reference to royal jelly creams, vitamin and hormone creams, antibiotic creams and a whole host of this range which have found very wide consumer acceptance.

More glaring however is the total omission of any reference to pressurised packs and aerosols. The latter is all the "rage" in the United States, very popular on the Continent, Japan and Australia and have made great strides even in the rather conservative United Kingdom. Indeed, there are experts who aver that pressurised packs and aerosols would extend their sway in the cosmetic world of tomorrow. It is to be hoped that an entire chapter would be devoted to these topics in the next edition of this useful book.

These limitations do not detract from the worth of this volume as a whole and the mass of data actually presented with care and precision. This book together with its two predecessors would justly rank as the *magnum opus* from one of the tallest figures in the British cosmetic and perfumery world.

M. N. SUBBA RAO.

General Zoological Microtechniques. By Frances M. Weesner. (William & Wilkins Co., Baltimore), 1960. Price \$ 5.25.

A thorough training in microscopic techniques at the graduate level is a prerequisite for students hoping to take up a research career. This book embodies the experience gained by the author during a period of ten years in handling such a course at the University of California, Berkeley. "There is no 'universal technique' which will work equally well for all materials, nor unfortunately, for all technicians". The descriptions and exercises deal with 'classical techniques' which have stood the test of time and detailed directions as to how the material should be handled are given.

Students learning micro-techniques would find this book valuable. M. K. SUBRAMANIAM.

Books Received

Introduction to Quantum Mechanics. By R. H. Dicke, J. P. Wittke. (Addison-Wesley Pub. Co., Reading, Mass., U.S.A.), 1960. Pp xi + 369. Price \$ 8.75.

Grasses of Burma, Ceylon, India and Pakistan. (Excluding Bambuseæ). By N. L. Bor. (Pergamon Press Ltd., Headington Hill Hall, Oxford), 1960. Pp. xviii + 767. Price f 8.

Cambridge Monographs on Mechanics and Applied Mathematics—The Rotation of the Earth—A Geophysical Discussion. By W. H. Munk and G. J. F. Macdonald. (Cambridge University Press, London N.W. 1), 1960. Pp. xix + 323. Price 70 sh.

Qualitative Organic Analysis. By B. Haynes. (Cleaver Hume Press, 31, Wrights' Lane, Kensington, London, W. 8), 1961. Pp. 239. Price 17 sh. 6 d.

Cytogenetics and Plant Breeding. By N. Krishnaswamy and S. N. Chandrasekharan. (P. Varadachary & Co., Madras-1), 1960. Pp. xv + 653. Price Rs. 25.

Pure and Applied Mathematics (Vol. X)—Lectures on Differential and Integral Equations. By K. Yosida. (Interscience Pub., New York-1, N.Y.), 1960. Pp. ix + 220. Price \$ 7.00.

Indian Tobacco—A Monograph. (Indian Central Tobacco Committee, Madras-6; The Business Manager, I.C.A.R. New Delhi-2), 1960. Pp. xx + 413. Price Rs. 36.

Interscience Tracts on Physics and Astronomy—An Introduction to Celestial Mechanics. By Theodore E. Sterne. (Interscience Pub., New York), 1960. Pp. xi + 206. Price \$ 4.50. Cloth Bound ; \$ 2.50 Paper Bound.

Space Flight Technology. Edited by K. W. Gatland. (Academic Press, Inc., 17 Old Queen Street, London S.W. 1), 1960. Pp. xv + 365. Price 75 sh.

Advanced Euclidean Geometry—An Elementary Treatise on the Geometry of the Triangle and the Circle. By R. A. Johnson under the Editorship of J. W. Young. (Dover Publications, New York), 1960. Pp. xiii + 314. Price \$ 1.65.

Symposia of the Society for Experimental Biology, No. XIV—Models and Analogues in Biology. (Cambridge University Press, London N.W. 1), 1960. Pp. vi + 255. Price 50 sh.

SCIENCE NOTES AND NEWS

Double Phlox

Dr. P. C. Tandan, Civil Surgeon, Shahjahanpur, writes :

Last year a variant Phlox Drummondii flower with a central tuft of small and rudimentary petals arising from the upper end of the corolla tube was noticed. By a process of cross-pollinations it was desired to observe if this variant characteristic (which could as well be mutant) was transmitted to the second generation.

A large number of variants have been observed and out of more than 300 specimens which have been examined so far, the most outstanding is the one which has got a central tuft of petals (see Fig. 1). This change has been observed



Fig. 1

in several plants raised from the seeds produced last year by the pollen from the variant flower. The transmission of the characteristics to the second generation suggests mutation. Observations and experiments are being continued to see if this characteristic becomes fixed in the next generation.

Award of Research Degree

Gujarat University has awarded the Ph.D. Degree in Physics to the following students of the Physical Research Laboratory, Ahmedabad, for the theses noted against their names :—

- (1) Shri S. R. Sreenivasan, "The distribution of electrons in the ionosphere from vertical soundings";
- (2) Shri U. R. Rao, "A study of time variations of cosmic rays with directional telescopes at Ahmedabad";
- (3) Shri H. S. Ahluwalia, "The study of time variations of cosmic rays at low and intermediate latitudes";
- (4) Shri R. V. Bhonsle, "Studies in ionospheric physics using extra-terrestrial radio-noise".

Symposium on History of Sciences in India

A Symposium on the History of the Development of Sciences in India will be held on August 4 and 5, 1961, in Calcutta.

The Symposium will cover the following broad fields of scientific developments in Ancient and Mediæval India : (a) Mathematics, Astronomy, Physics and Earth Sciences ; (b) Chemistry, Applied Chemistry and Technology ; (c) Medicine, Health, Biology and Agriculture ; (d) Social and International Relations in the Development of Sciences ; Teaching of the History of Sciences.

Further particulars can be had from Dr. A. C. Ukil, Convener, History of Sciences Board, National Institute of Sciences of India, Calcutta-16.

Indian Pharmaceutical Congress Association

The following were elected as Office-bearers of the Indian Pharmaceutical Congress Association for 1961-62. President : Dr. B. Mukherjee, Lucknow ; Hon. Gen. Secretary : Dr. D. Chakravarty, Calcutta ; Foreign Secretary : Dr. P. L. Seth.

International Society for Tropical Ecology—1962 Symposium

In response to the suggestion made at the first symposium on "Ecological Problems in the Tropics" held in Allahabad on February 3-5, 1961, the Society proposes to hold the second symposium in 1962, the place and the dates for which will be announced in due course and will be intimated to those who respond to this circular. The subject chosen for the 1962 symposium is "The Evaluation of Tropical Habitat for Production of Food, Fodder, Fuel and Fertilizers". Papers are invited on any of the topics coming under the above general heading. Abstracts of papers should be sent to the Gene-

ral Secretary by the 15th August and the full papers by November 1961. For further particulars please write to Dr. G. S. Puri, General Secretary, 10, Chatham Lines, Allahabad.

Salt Pseudomorph Shales from the Upper Vindhyan of Maihar-Rewah Area

Shri R. C. Misra, Department of Geology, Lucknow University, Lucknow, writes: During a visit to the Maihar-Rewah area, Madhya Pradesh, in December 1960, where an almost complete sequence of Lower and Upper Vindhyan are exposed, an array of beautifully preserved sedimentary structures was discovered. These consist of salt pseudomorphs, rain prints, pebble mark, worm track, flow-cast, drag folds in Sirbu shales; algal, boudinage, box-work, penecontemporaneous and swash mark structures in Bhandar limestone; flute casts in Rewah shales and rill marks in Rohtas shales.

The presence of salt pseudomorph shales in the Sirbus is of considerable importance to Vindhyan Geology. Such shales were so far known only from the Cambrian sequence of the Salt Range (Pakistan). The correlation of the Vindhyan sandstones has been done with the purple sandstones of the Salt Range. The present discovery strengthens this correlation.

Annular Low Pressure Mercury Lamp

The many advantages of using low pressure mercury lamps for exciting Raman spectra are well known. Each laboratory has its own type of low pressure lamps to suit the nature of the investigation in hand. A horizontal annular type with two liquid-mercury electrodes separated from the active discharge region is described by two Russian scientists, Kondilenko and Vorobeva (*Optics and Spectroscopy*, 1960, 9, 273). The lamp is easy to make. Its high light output and good spectral properties, combined with the uniform and stable illumination it provides, make it specially suitable for routine qualitative and quantitative Raman spectra analysis.

The lamp consists of two coaxial cylinders, made of molybdenum glass, with diameters 30 and 70 mm., the annular clearance (the discharge region) between the walls being 20 mm. Tubular outlets are fused onto the opposite ends of the lamp for the electrodes (25 mm.) which are cooled internally with running water. The length of the working part of the lamp is 200 mm., the distance from the cylinder to the electrodes is 80 mm. A supplemental mercury electrode is provided near the cathode to facilitate ignition. After the ignition arc has burned

for a few seconds, and the cooling of the electrodes has begun, the lamp is ignited readily by touching the glass surface of the electrode vessel with the discharge from a small high frequency generator (80 kc.). The lamp is fed from 110 volt dc power supply. It works steadily from 6 to 25 amps. and working at 16 amps. is recommended for normal work.

To obtain Raman spectra, the cuvette with the substance under investigation and the cooler are inserted in the inner cylinder. Coating the outer cylinder with magnesium oxide and blackening the farther end of the lamp, help to increase the light falling on the experimental cuvette and avoid stray scattering in the direction of observation. With a fast spectrograph (ISP-51), a satisfactory Raman spectrum of CCl_4 showing the anti-stokes components, also could be obtained in 15 seconds.

The Double-Pass Jamin Interferometer

In a paper contributed to the *British Journal of Applied Physics*, Hariharan and Sen, of the National Physical Laboratory, Delhi, have discussed the application of the principle of three-beam interference to obtain increased accuracy in measurements of small angular displacements. They have also described a modified three-beam interferometer for small angular measurements.

When the rays emerging from a Jamin interferometer are reflected back through the instrument, fringes similar in appearance and behaviour to three-beam fringes are obtained. These fringes can be used to measure small angular displacements of one of the beam-dividing plates with an accuracy of $0.01''$.—(*British J. App. Phys.*, 1961, 12, 20).

Interplanetary Magnetic Field and the Auroral Zones

The discovery of a regular interplanetary magnetic field by space probes (like Pioneer V) has reawakened interest in Hoyle's suggestion that the primary auroral particles are accelerated at neutral points in the combination of an interplanetary field and the geomagnetic field. Hoyle pointed out that the latitude of the aurora would depend on the distance of the neutral points from the earth and hence on the interplanetary field strength in the observed sense.

In a letter communicated to the *Physical Review (Phys. Rev. Letters)*, 1961, 6, 47) J. W. Dungey considers a model with interplanetary plasma moving relative to the earth, this "wind" lying approximately in the ecliptic plane, and an interplanetary field pointing roughly southward. On this model the connection between

the neutral points and auroras becomes obvious. The model predicts an asymmetry for auroras : for a "wind" from the sun there should be proton auroras before midnight and electron auroras after midnight. Recent results from IGY data are of great interest in connection with the model presented here and promise substantial advances in our understanding of the subject.

Acoustic Radiation by Insects

Reporting on the source of energy responsible for acoustic radiation by insects, Prof. Wigglesworth of Cambridge said that in the case of the common midge which emits a frequency of about 1000 cycles, the frequency is controlled by elasticity and inertia of the muscles of the animal's body. The power output is due to enzymes working on fats or sugars, which can release energy at the rate of about 500 calories per gram of muscle per hour. This is greatly in excess of the power production of the muscles in man.—(*J. Acous. Soc. Amer.*, 1961, 33, 98).

Structure of Vitreous Ice

Investigations using such techniques as thermal analysis, electron diffraction, and X-ray diffraction have shown that there are three possible phases of ice at low temperatures and pressures, namely, hexagonal (usually called ice I), diamond cubic, and vitreous. X-ray diffraction studies have shown that the hexagonal model is built up of layers of oxygen atoms, each layer consisting of a network of open puckered hexagonal rings. Each additional layer is a mirror-image of the preceding layer, so that the stacking is of the A.B.A.B.... sequence. The cubic model also may be considered as being built up in layers of oxygen as above, with the modification however that each successive layer is shifted one-half the diameter of the hexagonal ring, leading to the A.B.C.A.B.C.... stacking sequence typical of the diamond cubic system.

Results of recent investigations by X-ray diffraction method reported by Dowell and Rincret throw some light on the structure of vitreous ice (*Nature*, 1960, 188, 1144). They

have studied the temperature ranges in which the various phases exist and the rates of transformation from one phase to another. They have been able to produce vitreous ice only by condensing water vapour on a surface maintained below -160°C . This vitreous ice undergoes a partial and irreversible change to cubic ice at temperature above -160°C , the rate of transformation being strongly dependent on temperature. The mixed cubic-vitreous phase undergoes an irreversible transformation to hexagonal ice I at temperatures above -130°C , the rate again being temperature-dependent.

The X-ray diffraction pattern of vitreous ice is characterized by two intensity maxima, one at 24° (2θ) corresponding to a Bragg spacing of 3.71 \AA and the other at 42° corresponding to 2.15 \AA . These results show that the structure of vitreous ice is different from that of water at ordinary temperature. Also it is to be noted that attempts to produce vitreous ice directly from liquid water prove unsuccessful, and the condensation of pure water vapour is the most reliable and practical method of producing vitreous ice.

The observed results on the diffraction patterns and rate transformations may be explained on the basis that in vitreous ice domains exist in which there is a tendency toward the same layer structure present in the crystalline phases, although with random distribution of molecules within the layers. Those domains having very nearly the same layer spacing as the crystalline phases are apparently quite stable, but those having greater disorder are unstable. At temperatures above -160°C , crystallization to the cubic phase begins spontaneously at a few sites in the unstable zones, and the crystallites at each site quickly grow to about 400 \AA , where further growth is hindered by the more stable zones. Further crystallization takes place at new sites in the unstable domains, the process continuing until all such areas have crystallised. This state is now stable at all temperatures below -130°C . Above -130°C , both the cubic and the remaining vitreous ice begin to show conversion to the stable hexagonal phase, the individual crystallites growing to moderate size, about $10\text{ }\mu$.

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All material intended for publication and books for review should be addressed to the Editor, *Current Science*, Raman Research Institute, Bangalore-6.

Business correspondence, remittances, subscriptions, advertisements, exchange journals etc. should be addressed to the Manager, Current Science Association, Bangalore-6.

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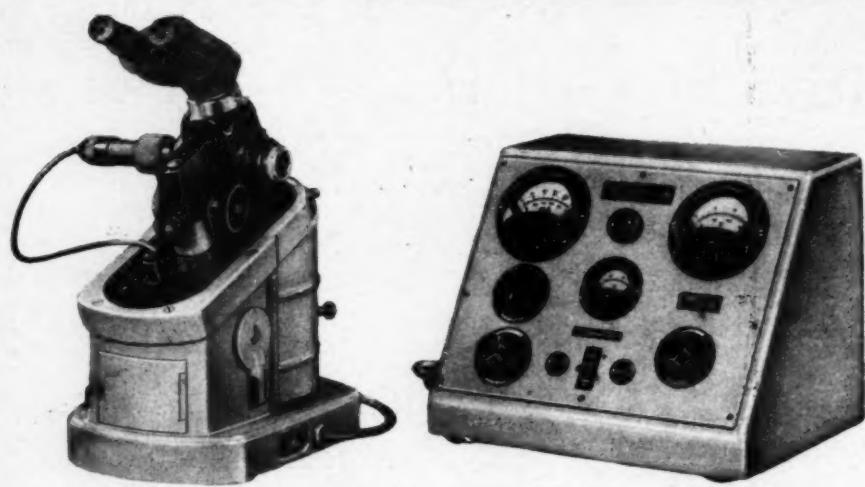
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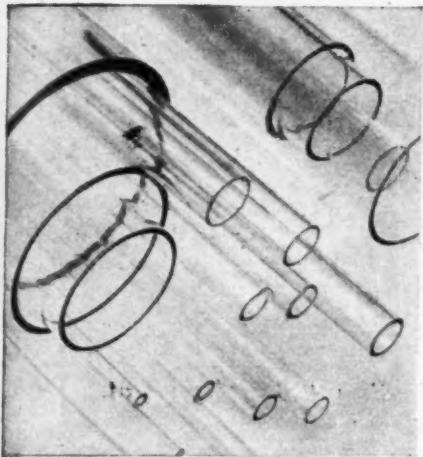
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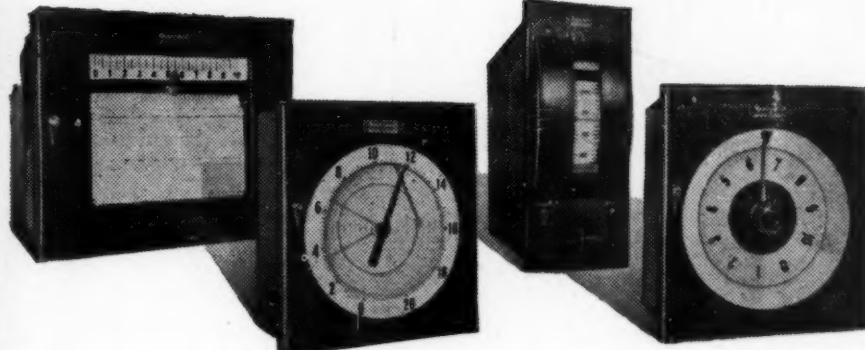
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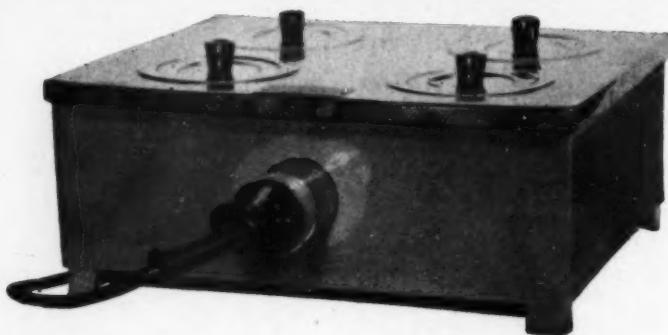
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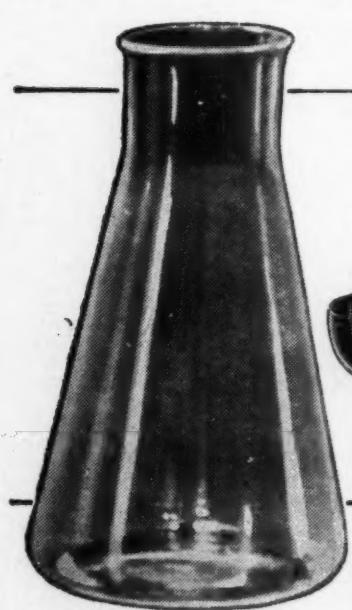
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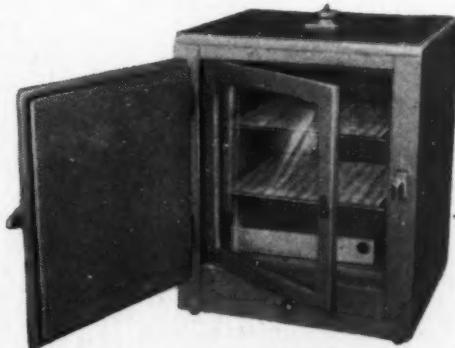
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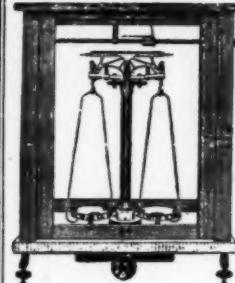
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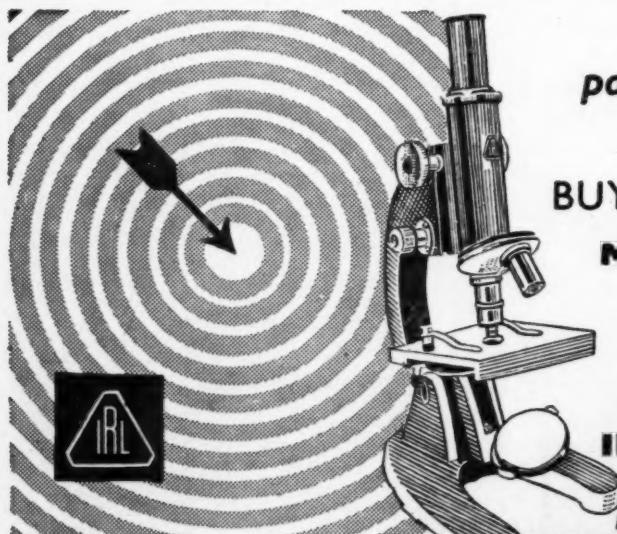
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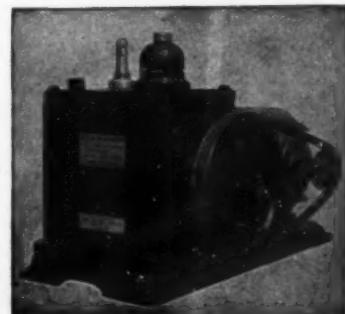
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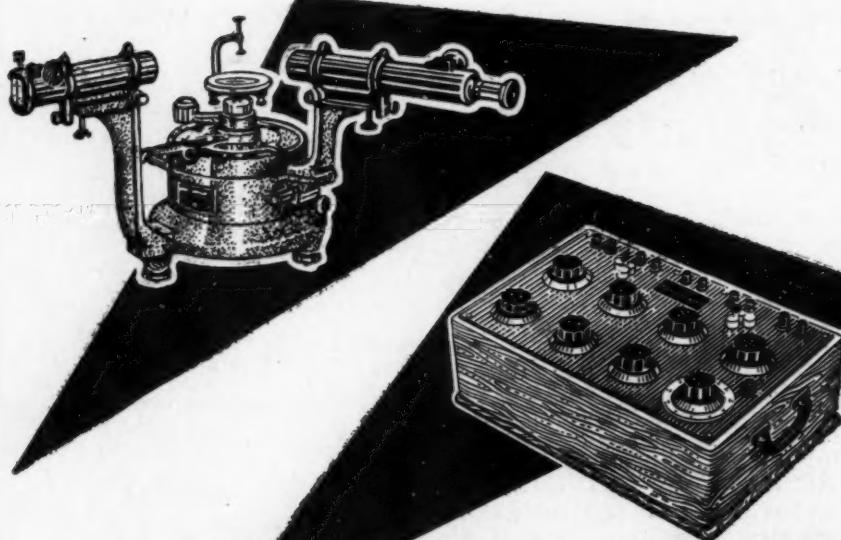
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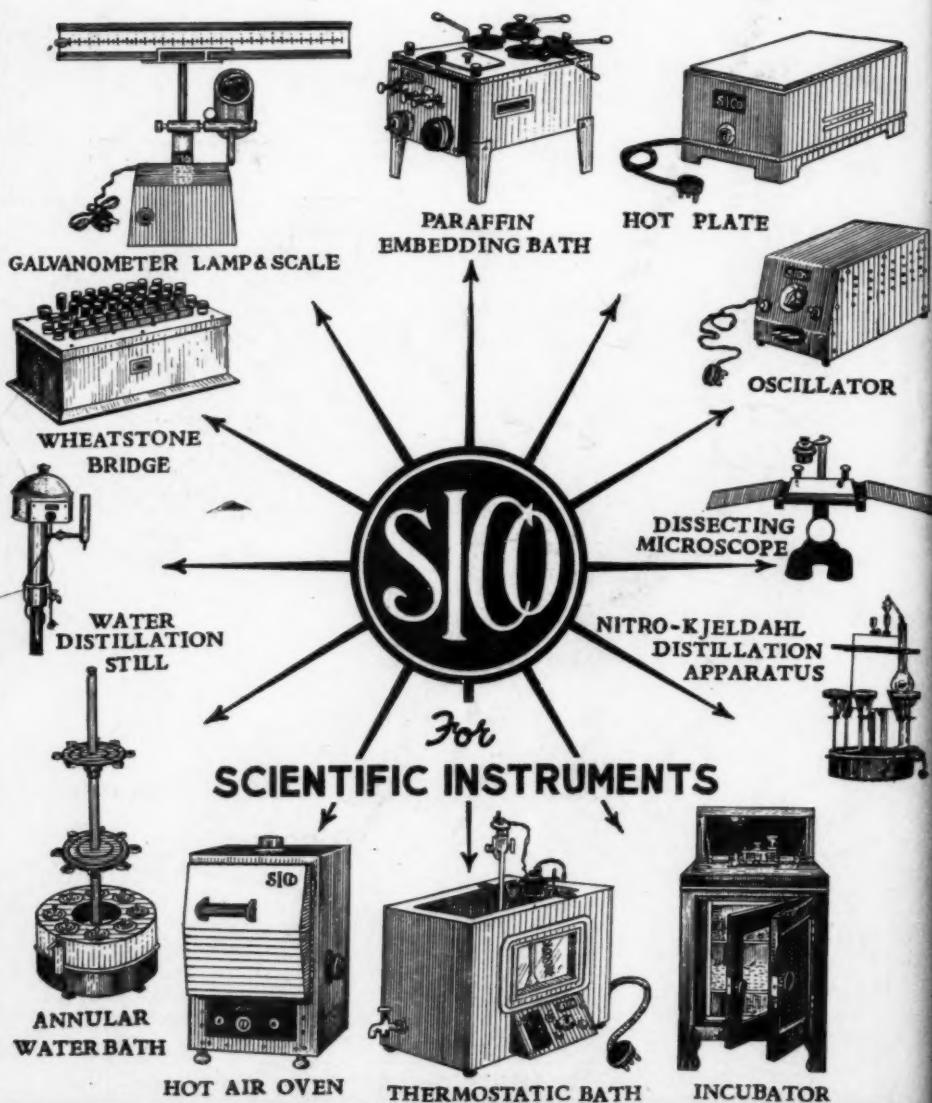
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